

# INSTRUCTION MANUAL

PART TWO

AERODYNAMIC THERMAL SIMULATION  
SYSTEM

SYSTEM CONTROLS

National Aeronautics and Space Administration  
George C. Marshall Space Flight Center  
Huntsville, Alabama 35812

(Reference: Contract Number NAS8-26416)



R-I CONTROLS DIVISION

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## SECTION 1 - INTRODUCTION

### 1-1

#### Scope

This instruction manual describes the 36 zone Thermal Simulation System and contains information on its operation and maintenance.

### 1-2

#### Level of Information

Discussions in this instruction manual assume the reader has a basic knowledge of electronics and is familiar with electronic terms and symbols.

### 1-3

#### Related Reference Material

The following references, located in the Related Reference Material Manual, will be used in the operation and maintenance of the system in conjunction with this manual.

Fundamentals of Proportional Temperature Control

Model 624A Temperature Controller Instruction Manual

Model FGE 5110 DATA-TRAK Programmer Instruction Manual

Model HI-D3-645 Power Regulator Instruction Manual

Model 607 Match-Pack Instruction Manual

Acopian Power Supply Instruction Manual

## SECTION 2 - SYSTEM DESCRIPTION

2-1

### General Description

The 36 zone thermal radiation simulation system controls the surface temperature of a large test article. An array of radiant heat sources surrounding the test article emits directional radiant energy to heat the test article. The heat applied is controlled according to a predetermined time/temperature program.

The 36 individual temperature zones are combined into three main groups comprised of 9 top zones, 12 side zones, and 15 bottom zones. A separate temperature programmer is utilized for each of the 3 main groups and each Programmer may have a different time/temperature profile.

Each zone is an independent "closed loop" temperature control circuit. Figure 2-1 is a block diagram of one representative control zone.

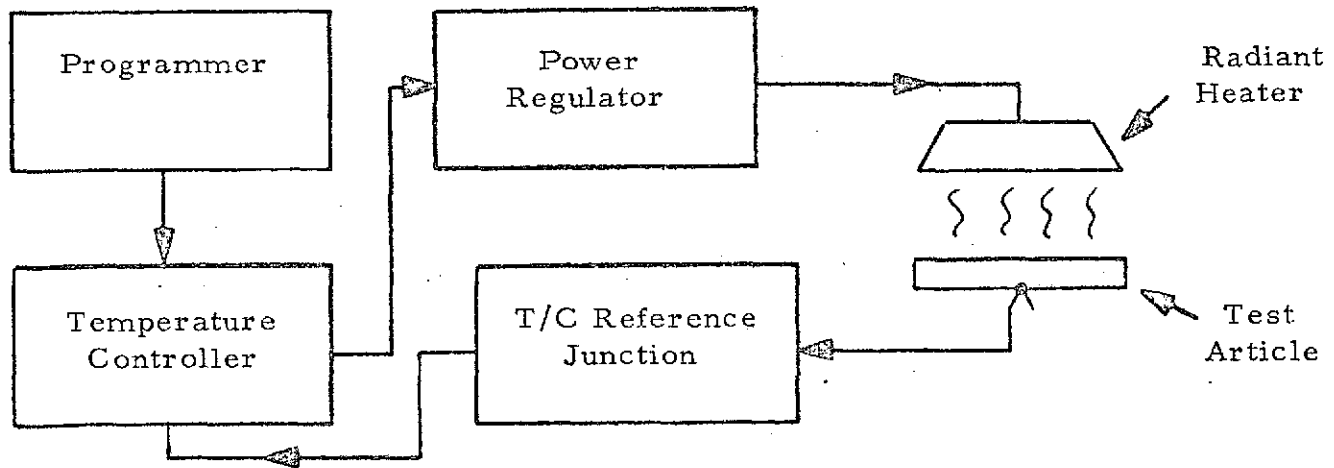


Figure 2-1 Representative Zone Block Diagram



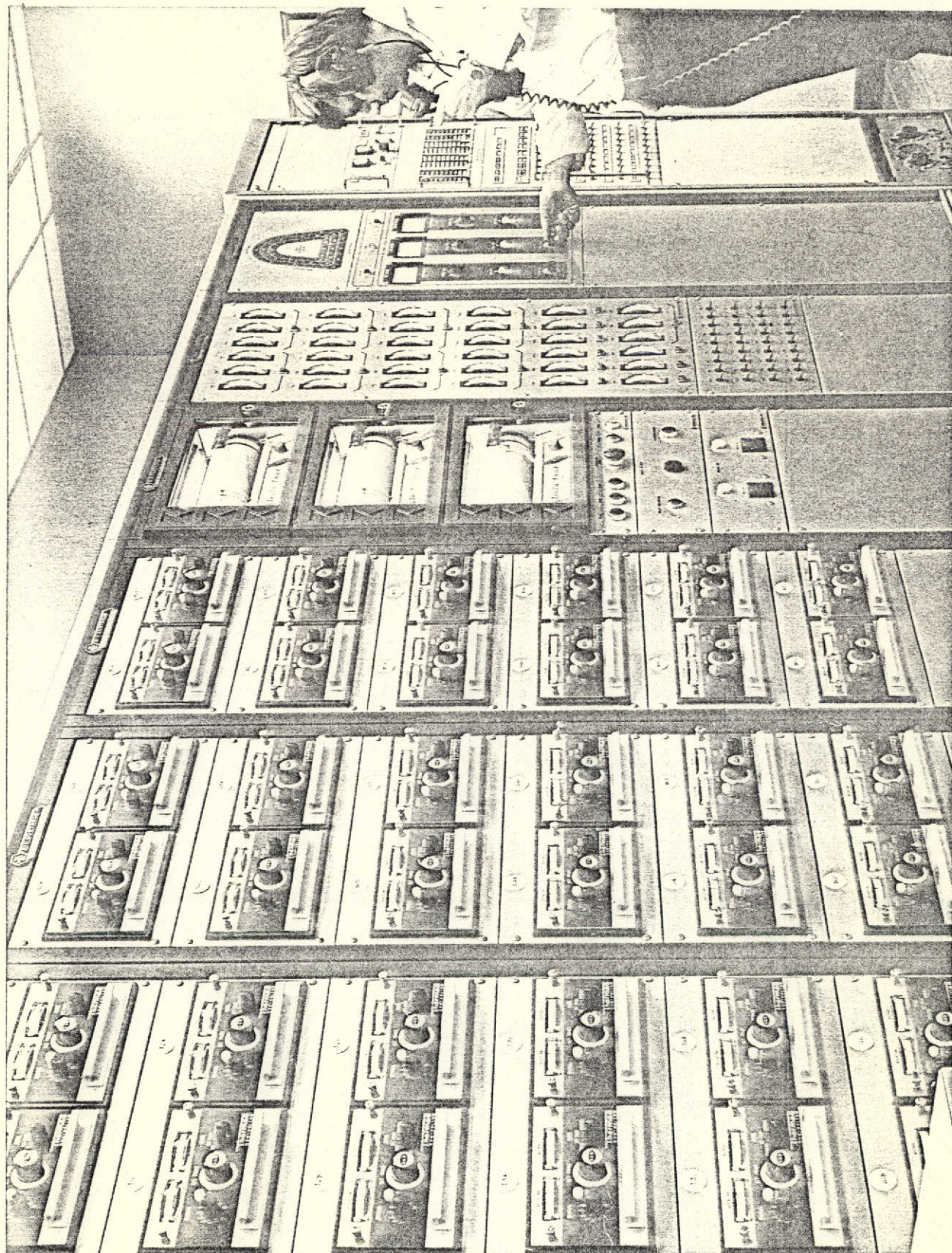


Figure 2-2 The Control System



The thermocouple feeds back a voltage to the temperature controller that is proportional to the temperature of the test article. The temperature controller compares the actual temperature with the desired temperature and outputs an error command to the power regulators. If the actual temperature is lower than the desired temperature, the power level to the radiant heater is increased. If the actual temperature is higher than desired, the power level is decreased.

## 2-2            Main System Components

Besides the Radiant Array, the main system components consist of the Temperature Programmers, the Temperature Controllers, and the Power Regulators.

### 2-2-1            The Programmer

The Programmer used in the system is a Model FGE5110 DATA-TRAK Programmer. Refer to the instruction manual found in the Related Reference Material for specific information on this equipment.

The Programmer provides the desired set point command to the Temperature Controller, provided the Temperature Controller is switched into Remote Set Point mode.

There are three Programmers in the system, one for the top zones, one for the side zones, and one for the bottom zones.

### 2-2-2            The Temperature Controller

The Temperature Controller used is a Model 624A Controller with the Rate and Reset option. There are 36 of these controllers, one for each control zone. Refer to the Model 624A Controller manual found in the Related Reference Material for specific information on this equipment.

The Temperature Controller compares the desired set point temperature with the actual temperature of the test article and supplies an amplified error signal to the Power Regulators.

### 2-2-3            The Power Regulators

The Power Regulators are Model HI-D3-645 Regulators that utilize distributed zero crossover firing for reduced RFI and EMI generation. Refer to the instruction manual found in the Related Reference Material for specific information on this equipment.

The Power Regulators vary the power level to the Radiant Heat Array to maintain the test article at the desired temperature.



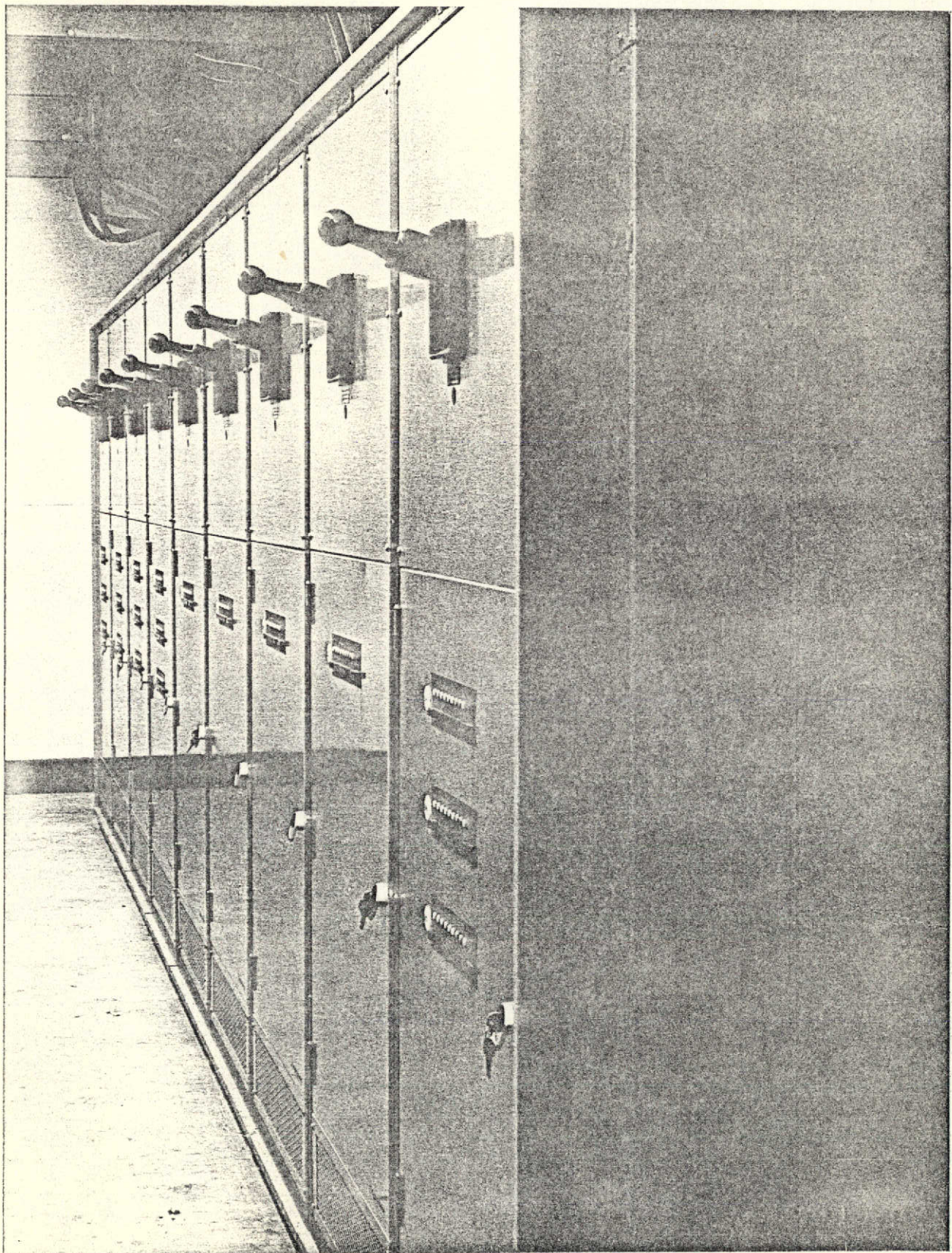


Figure 2-3 The Power Regulators



## SECTION 3 - OPERATOR CONTROLS AND INDICATORS

### 3-1

### General

The following paragraphs describe the various operator controls and indicators found on the front panels of the control racks. Operator controls of the Temperature Controller and Temperature Programmer are covered in their respective manuals found in the Related Reference Material Book.

### 3-2

### Operator Controls and Indicators

Table 3-1 lists the controls and indicators found on the front panels of the control racks and briefly describes their functions. It is intended only to familiarize the operator with the controls and indicators prior to operating the system.

Table 3-1 System Controls and Indicators

| Programmer Rack #4 |                              |   |
|--------------------|------------------------------|---|
| NAME               | TYPE                         | FUNCTION  |
| POWER ON - 28 VDC  | Circuit Breaker              | Closed - Applies 28 VDC to control system   |
| POWER ON - 28 VDC  | White Indicator Lamp         | Lighted - Indicates 28 VDC circuit breaker is closed  |
| POWER ON - 120 VAC | Circuit Breaker              | Closed - Applies 120 VAC to control system  |
| POWER ON - 120 VAC | White Indicator Lamp         | Lighted - Indicates 120 VAC circuit breaker is closed   |
| FAULT INDICATOR    | Red Indicator Lamp           | Lighted - Indicates blown fuse, insufficient water flow, or Emergency Stop fault in a Power Controller Rack |
| FAULT ALARM        | Sonalert                     | Audible alarm device-sounds when fault light is lit   |
| ACKNOWLEDGED       | Momentary push-button switch | Depressed - Mutes the audible warning device  |
| START              | Momentary Push-button Switch | Depressed - Puts system into a run condition  |

|  |                                 |  |
|--|---------------------------------|--|
| RUN  | Green Indicator Lamp            | Lighted - Indicates system is in a Run condition   |
| STOP   | Momentary Pushbutton            | Depressed - Takes system out of a Run condition  |
| HOLD   | Momentary Pushbutton Switch     | Depressed - puts system into a Hold condition (stops Programmers but holds existing temperature levels). Depress RUN pushbutton to resume.   |
| HOLD   | Amber Indicator Lamp            | Lighted - Indicates system is in a HOLD condition  |
| EMERGENCY STOP   | Momentary Pushbutton Switch     | Depressed - Opens all Power Regulator Cabinet circuit breakers   |
| Power Supply Select and Voltmeter Rack #5                  |                                 |  |
| T1A through B5C (36 zones)                                 | Voltmeter (0-500 VAC)           | Indicates load voltage of each control zone  |
|  | Amber Indicator Lamp (18 total) | Lighted - Indicates the circuit breaker of the appropriate Power Regulator Rack has been closed.   |
| T1A through B5C (36 zones)                                 | Maintained Action Toggle Switch | Up - permits the selected power regulator to supply warmup power to the corresponding zone in the radiant array.<br>Down - prevents that zone from going into run when system RUN pushbutton is depressed. |
| Cooling Gas and Water Flow Control Rack #6                 |                                 |  |
| Array cooling water loss warning top & side - bottom-drain | Red Indicator Lamps (3)         | Lighted - Indicates cooling water loss in the area of the lamp that is lit.  |

|                                   |                            |  |
|-----------------------------------|----------------------------|--|
| Manifold pressure top-side-bottom | Panel Meter (3)            | Indicates manifold pressure (scaled 0 - 150 p.s.i.)  |
| Control zone                      | Rotary Selector Switch (3) | Selects the master cooling controller for each of the 3 regions (Normally the zone requiring the most cooling would be selected).                    |
| Mode SELECT                       | Rocker Switch (3)          | <u>AUTO</u> - Control of array cooling will be "closed-loop" controlled.<br><br><u>MANUAL</u> - Control of Array cooling will be manually controlled |
| MANUAL ADJUST                     | Potentiometer (3)          | Allows manual control of cooling in any region, provided the MODE SELECT switch is set to MANUAL position.   |



## SECTION 4 SYSTEM OPERATION

### 4-1 General

This section will outline the procedures used for starting and stopping the system.

### 4-2 System Start Procedures

Table 4-1 lists the starting procedures and normal indications for operating the system.

Table 4-1 System Start-up Procedures

| INSTRUCTION   | NORMAL INDICATION  |
|---|--|
| 1. Open cooling gas and water valves to Array and Power Regulators.               |  |
| 2. Close the 120 VAC and 28 VDC circuit breakers on control panel.                | - POWER ON indicators will light   |
| 3. Set Data-Trak Programmer mode switches to REMOTE.                              |  |
| 4. Set Temperature Controller mode switches to PROGRAM.                           |  |
| 5. Select cooling gas control zone for the 3 regions [MODE SELECT switch in AUTO] |  |
| 6. Close individual Power Regulator rack circuit breakers.                        | - Appropriate amber indicator lamps on control panel will light.         |
| 7. Select the desired power supplier in sequence                                  | (Warmup power supplied to Array)   |
| 8. Depress START pushbutton   | Green RUN indicator will light and Programmer drums will start rotating. |

#### 4-3

#### System HOLD

The HOLD pushbutton allows the operator to halt the system at a particular temperature without removing power to the Array. When the HOLD pushbutton is depressed, the Programmer drums stop rotating, and the HOLD indicator lights. Depressing the START pushbutton again, extinguishes the HOLD light and starts the Programmer drums rotating.

#### 4-4

#### System STOP

The STOP pushbutton allows the operator to interrupt power to the Array (except for warmup power). When the STOP pushbutton is depressed, the RUN indicator lamp extinguishes, and the power supplies are disabled, removing all power (except warm up power) to the Array. The system may be restarted by depressing the START pushbutton.

#### 4-5

#### Fault Indicator

The FAULT INDICATOR will light and the FAULT ALARM will sound if a fuse blows, circuit breaker trips, or there is insufficient water flow in one of the selected Power Regulator cabinets. The audible alarm may be muted by depressing the ACKNOWLEDGE pushbutton but the light will remain until the fault is corrected.

#### 4-6

#### Cooling Gas Inhibit

The photo function switches in each of the Data-Trak Programmers are used to enable or inhibit the cooling gas controllers so they will operate only on a decreasing heat condition. When the program requires a reduction of temperature, a strip of reflective tape placed around the circumference of the drum will energize the photo function switch circuit. A closed contact in the photo function switch circuit will allow the signal from the cooling amplifier to be applied to the cooling valves. On a rising heat condition, even with a temperature overshoot, the unenergized photo function switch circuitry will inhibit the cooling system.

Table 4-2 lists the procedures for shutting down the system.

Table 4-2 System Shut-Down Procedure

| INSTRUCTION  | NORMAL INDICATION   |
|--|---|
| 1. Depress the STOP pushbutton                               | RUN light will extinguish<br>Programmer drum will stop rotating |
| 2. Return Power Supply Select switches to down position      |   |
| 3. Depress EMERGENCY STOP pushbutton                         | Opens all Power Regulator circuit breakers.                     |
| 4. Open 28VDC and 120 VAC circuit breakers on control panel. | All system indicators and<br>POWER ON lamps extinguish          |
| 5. Close all cooling gas and water valves.                   |   |



## SECTION 5 SYSTEM MAINTENANCE

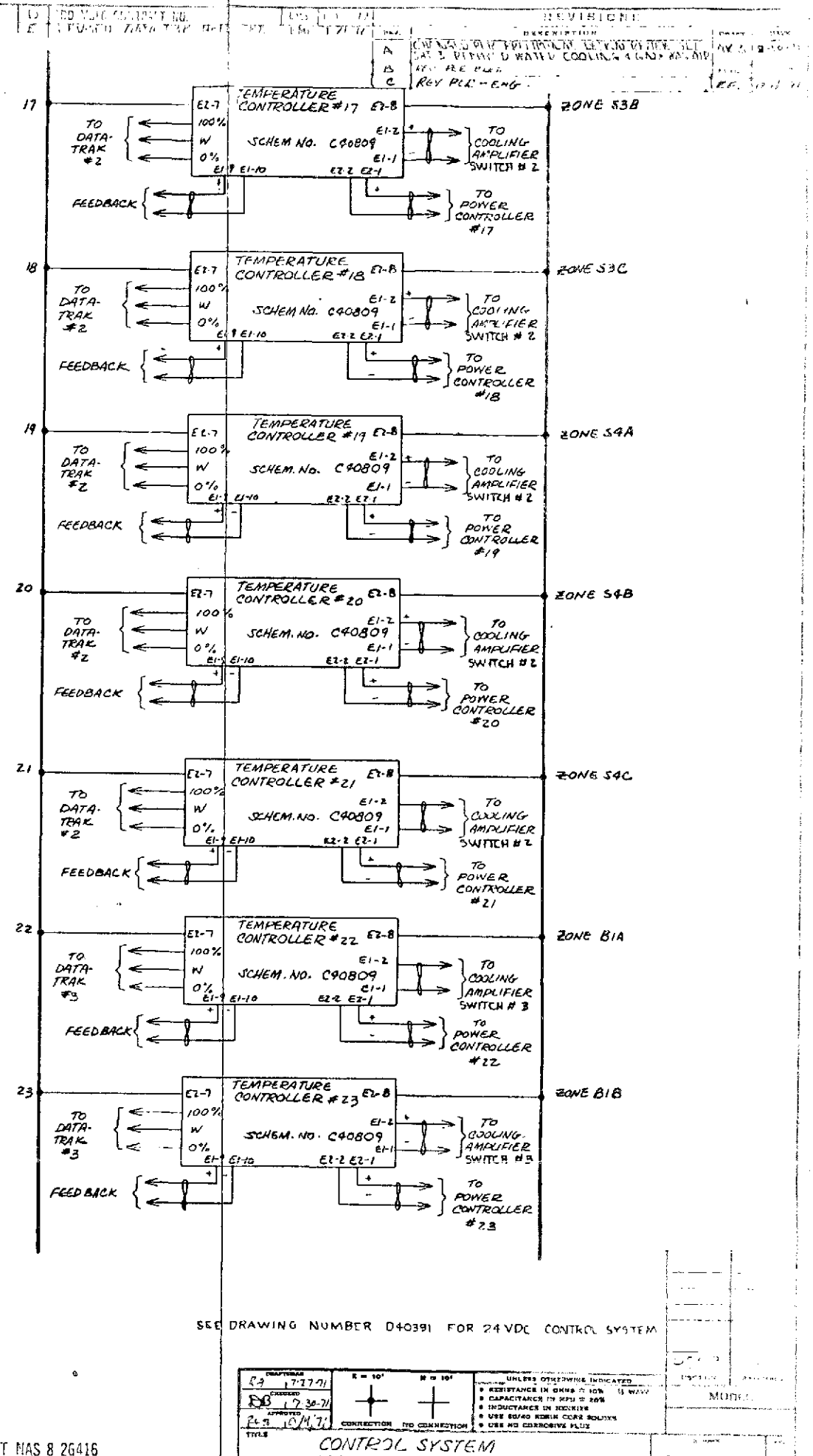
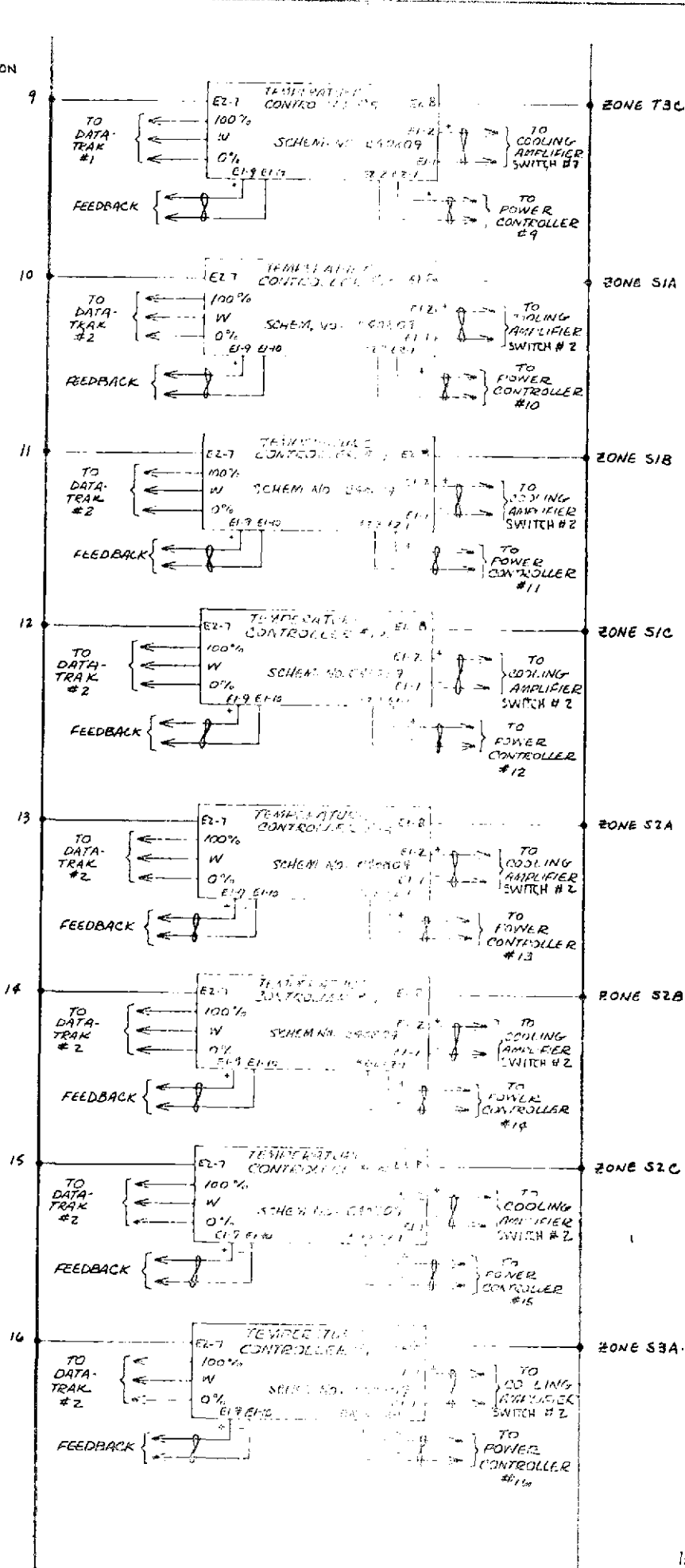
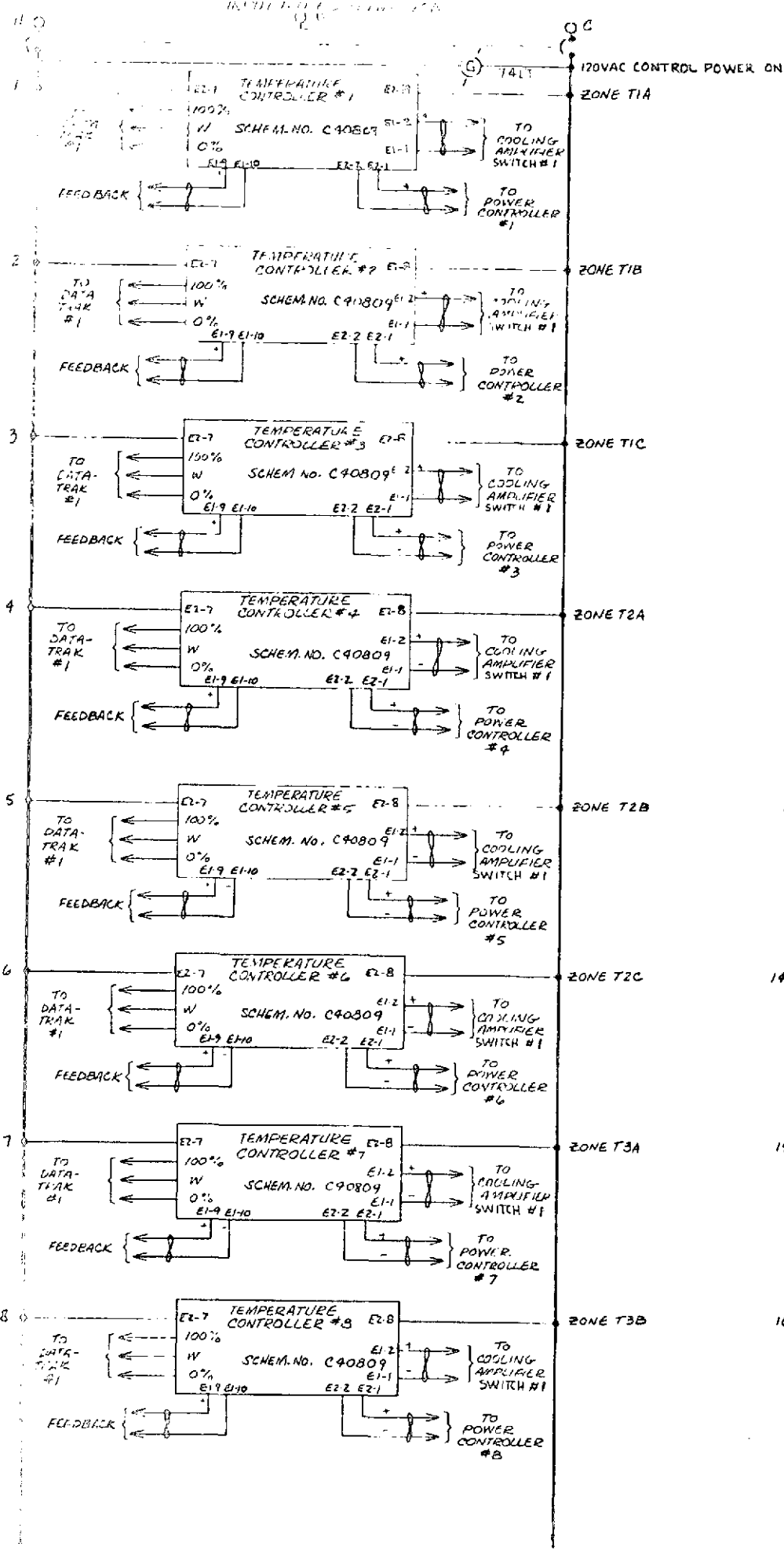
### 5-1      General

Control system maintenance will consist mainly of keeping the enclosures and components free from dust or other contaminants, and to change lamps or other indicators as burn-outs occur.

Component maintenance is covered in their individual instruction manuals found in the Related Reference Material manual.

## SECTION 6 SYSTEM SCHEMATICS

|        |                |  |
|--------|----------------|--|
| D40388 | Sheet 1,2, & 3 | Control System - Thermal Simulator                   |
| D41241 |                | Schematic - Cooling Interface Amplifier              |
| D41260 |                | Schematic - Cooling Controller                       |
| C41261 |                | Schematic - 6000 Thermac, 624A special               |
| D40391 | Sheet 1 & 2    | Electrical Functional - 28VDC Control System         |
| D41152 |                | Wiring Diagram - Master Control Console              |
| D41022 |                | Wiring Diagram - Temperature Control Rack #1         |
| D41023 |                | Wiring Diagram - Temperature Control Rack #2         |
| D41024 |                | Wiring Diagram - Temperature Control Rack #3         |
| D41043 |                | Wiring Diagram - Programmer Rack #4                  |
| D41047 |                | Wiring Diagram - Power Supply Select Rack #5         |
| D41069 |                | Wiring Diagram - Gas and Water Flow Rack #6          |
| D40392 |                | Interconnection Wiring Diagram For Thermal Simulator |
| D41316 | Sheet 1 & 2    | Interconnect Wiring - Power Controllers              |
| D40098 |                | Power Schematic Thermal Simulator (Functional)       |



SEE DRAWING NUMBER D40391 FOR 24VDC CONTROL SYSTEM

|  |                           |                            |  |
|--|---------------------------|----------------------------|--|
| DESIGNED BY<br>R. J. 17771   | CHECKED BY<br>R. J. 17771 | APPROVED BY<br>R. J. 17771 | TITLE<br>CONTROL SYSTEM<br>THERMAL SIMULATOR |
| UNLESS OTHERWISE INDICATED:<br>* RESISTANCE IN OHMS AT 100°<br>* CAPACITANCE IN P.F. AT 200°<br>* INDUCTANCE IN HENRIES<br>* USE 50/50 RATIO CORE BOLTS<br>* USE NO CORROSIVE FLUX |                           |                            | MODEL<br>SN. 17771                           |

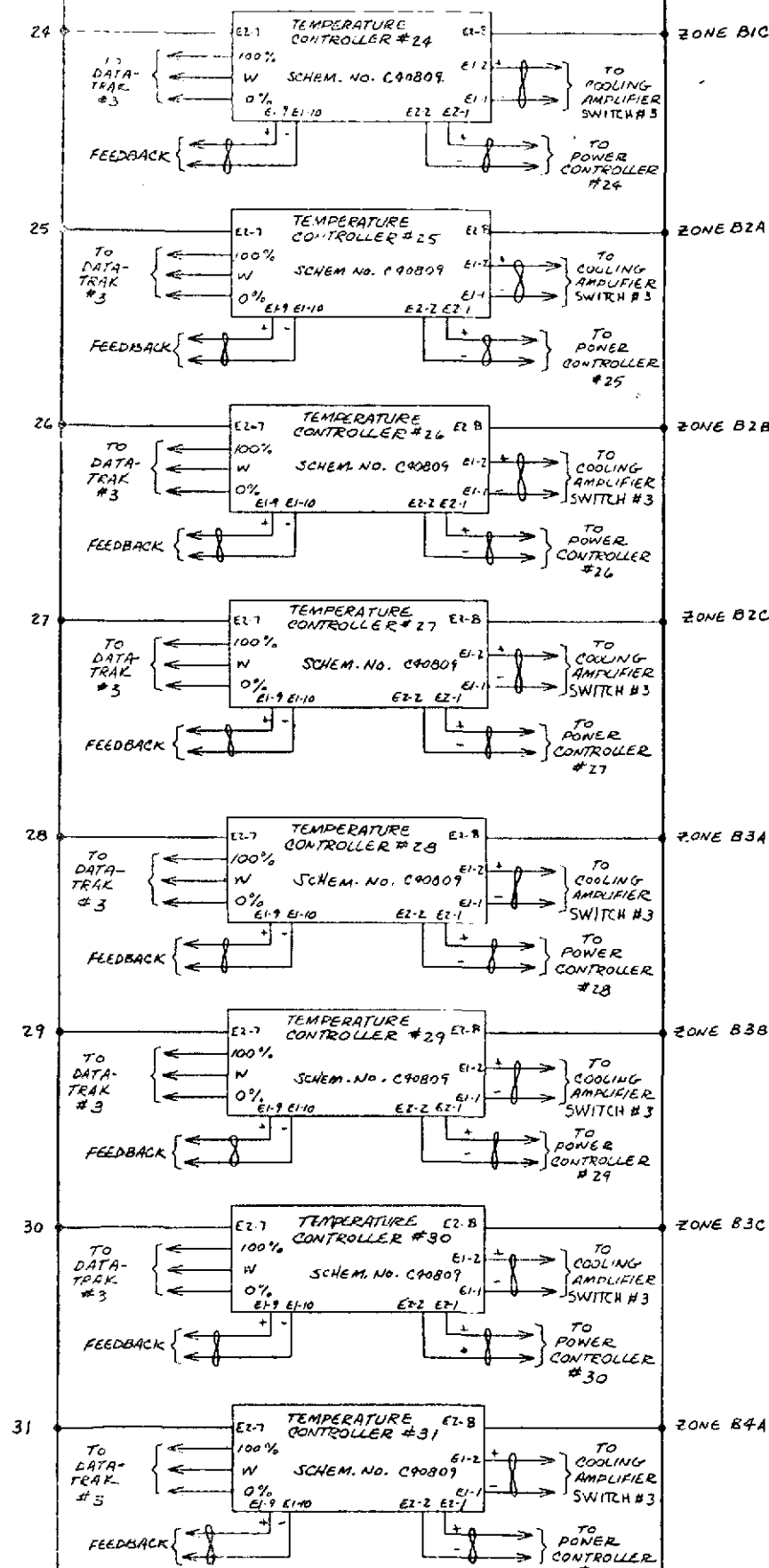
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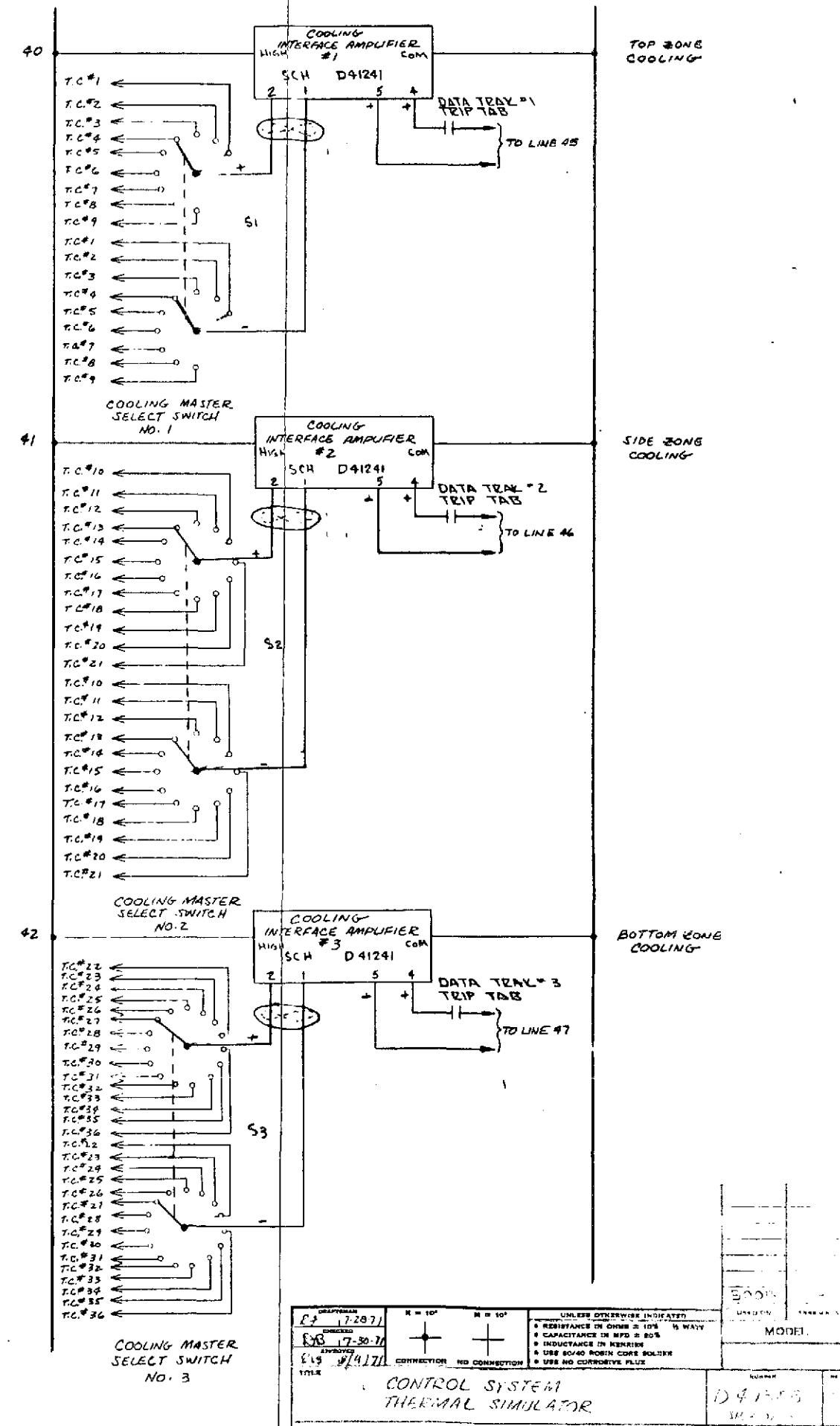
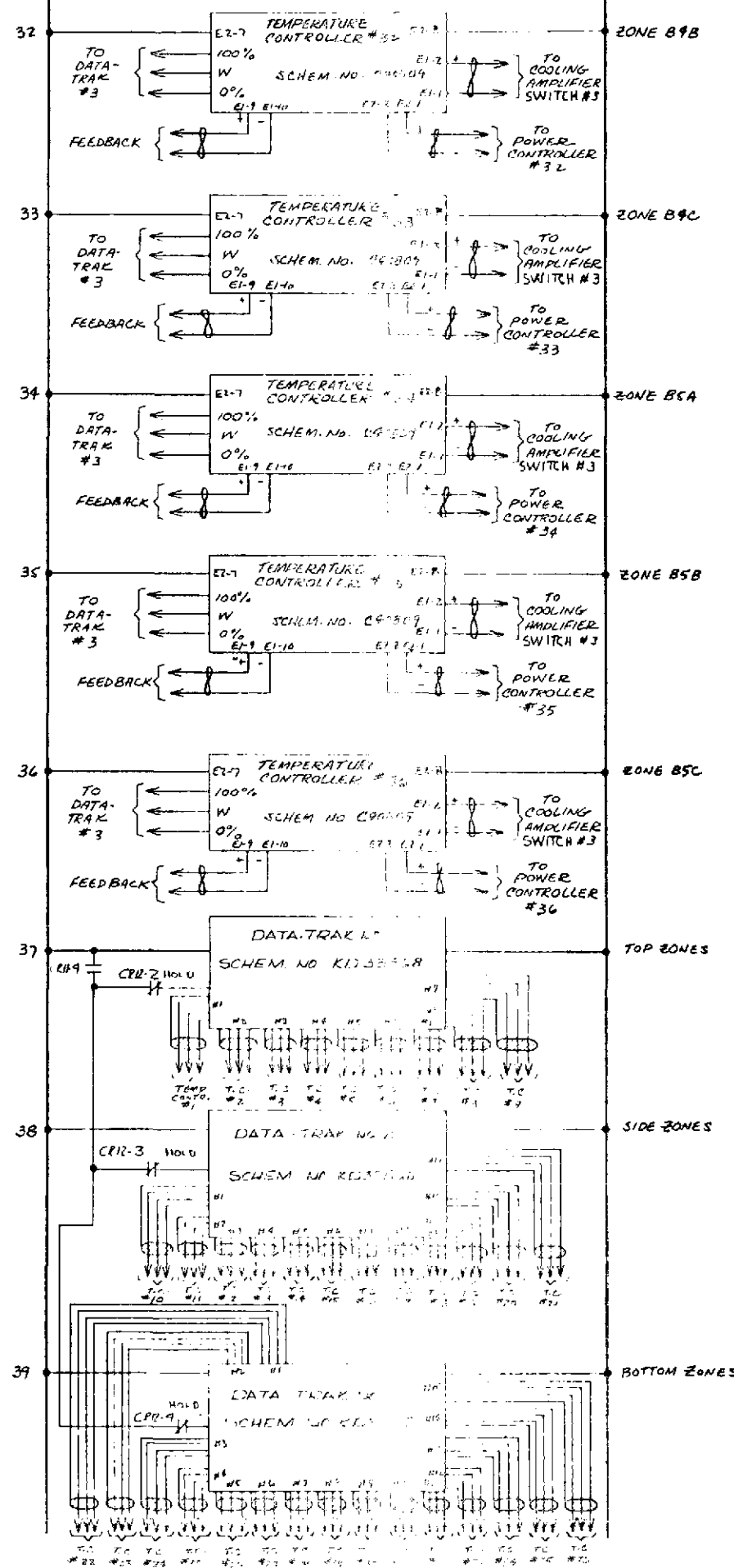
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|------------------------------|-----------------------------|-----------------|-----------------------------|

|   |  |                 |
|---|--|-----------------|
| UNLESS OTHERWISE INDICATED:<br>* RESISTANCE IN OHMS ± 10% 1/4 WATT<br>* CAPACITANCE IN MFD ± 20%<br>* INDUCTANCE IN KILOHMS<br>* USE 60/40 ROUGH CORE SOLDER<br>* USE NO CORROSIVE FLUX |  | MODEL<br>D41241 |
|---|--|-----------------|

|                                     |  |  |
|-------------------------------------|--|--|
| CONTROL SYSTEM<br>THERMAL SIMULATOR |  | RESEARCH INCORPORATED<br>WINNEPESKE, WISCONSIN |
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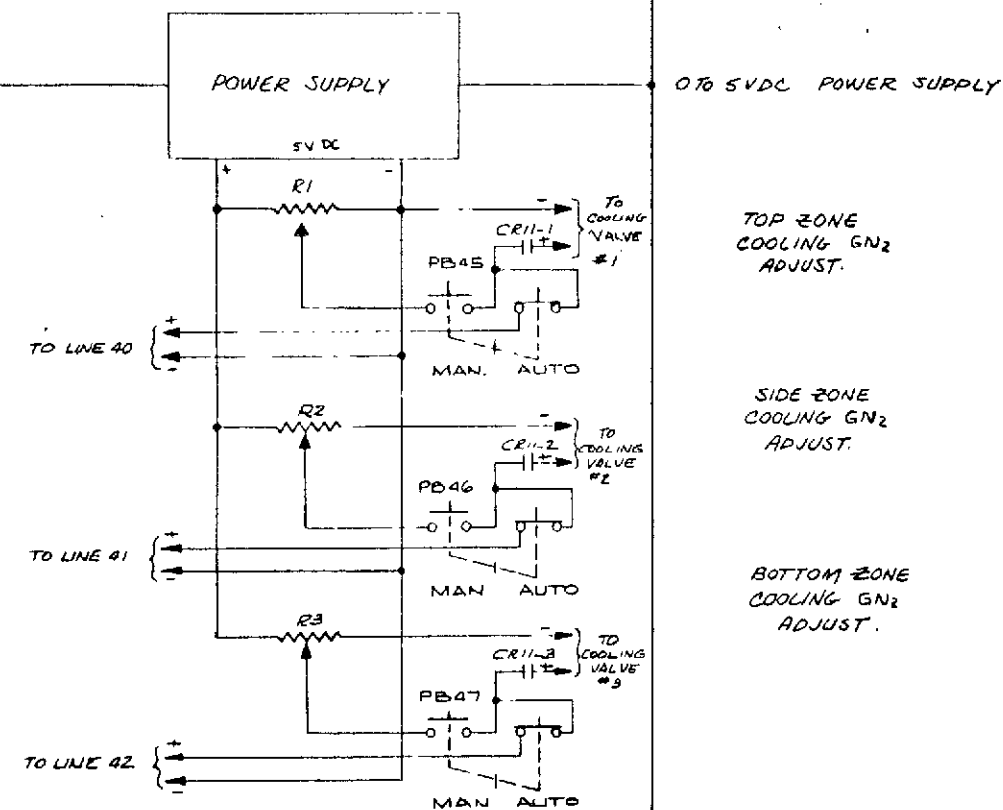
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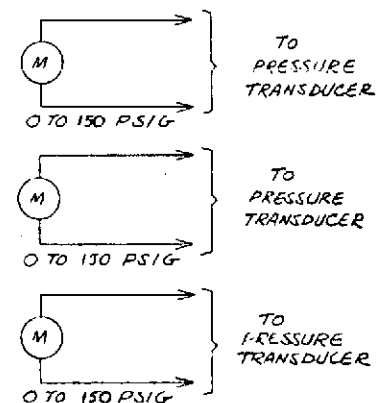
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TOP ZONE  
COOLING GN<sub>2</sub>  
ADJUST.

SIDE ZONE  
COOLING GN<sub>2</sub>  
ADJUST.

BOTTOM ZONE  
COOLING GN<sub>2</sub>  
ADJUST.



TOP ZONE  
MANIFOLD  
PRESSURE

SIDE ZONE  
MANIFOLD  
PRESSURE

BOTTOM  
ZONE  
MANIFOLD  
PRESSURE

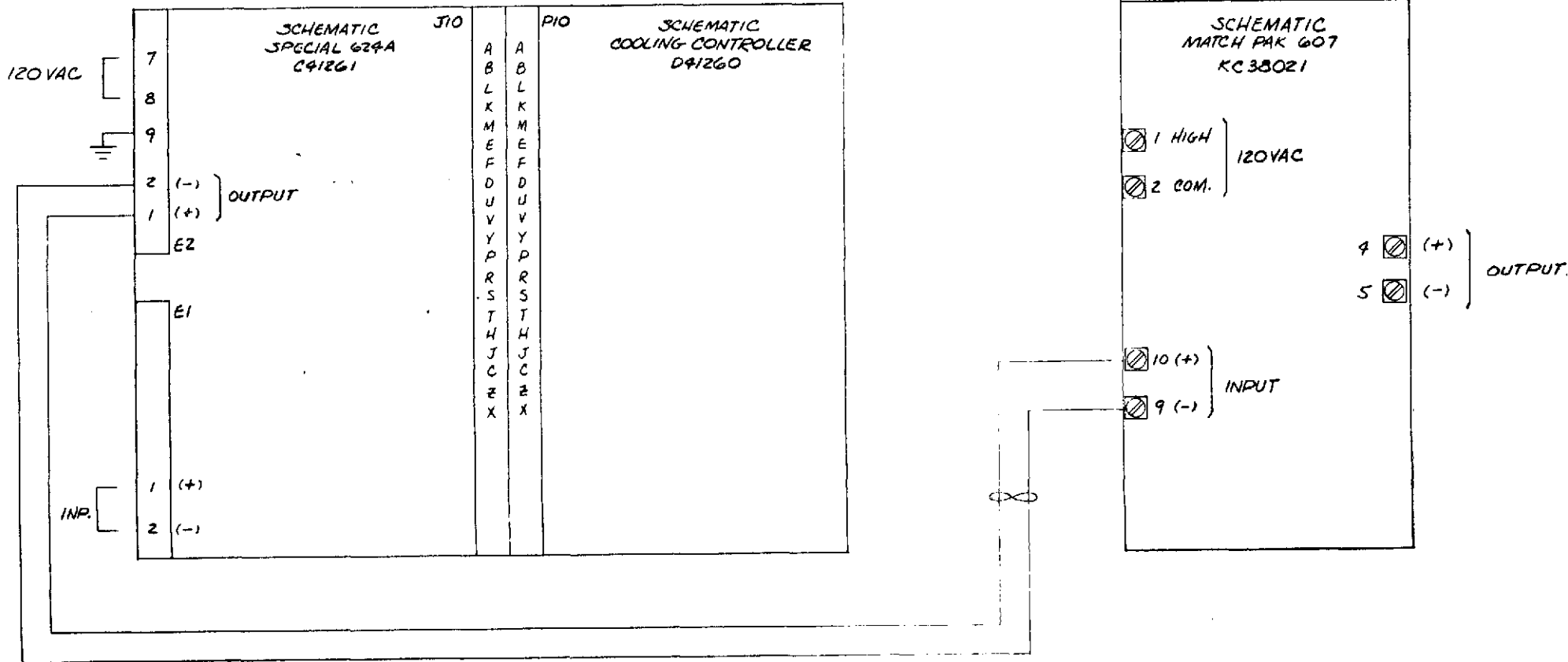
ARRAY  
COOLING  
GN<sub>2</sub>

|  |  |  |   |                            |
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| CONTROL SYSTEM<br>THERMAL SIMULATOR                                    |  | RESEARCH INCORPORATED MINNEAPOLIS, MINNESOTA |   |                            |

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| TITLE<br><b>SCHEMATIC - COOLING<br/>INTERFACE AMPLIFIER</b> |                         |                          |   | REV<br><b>A</b>        |
| RESEARCH INCORPORATED MINNEAPOLIS, MINNESOTA                |                         |                          |   |                        |

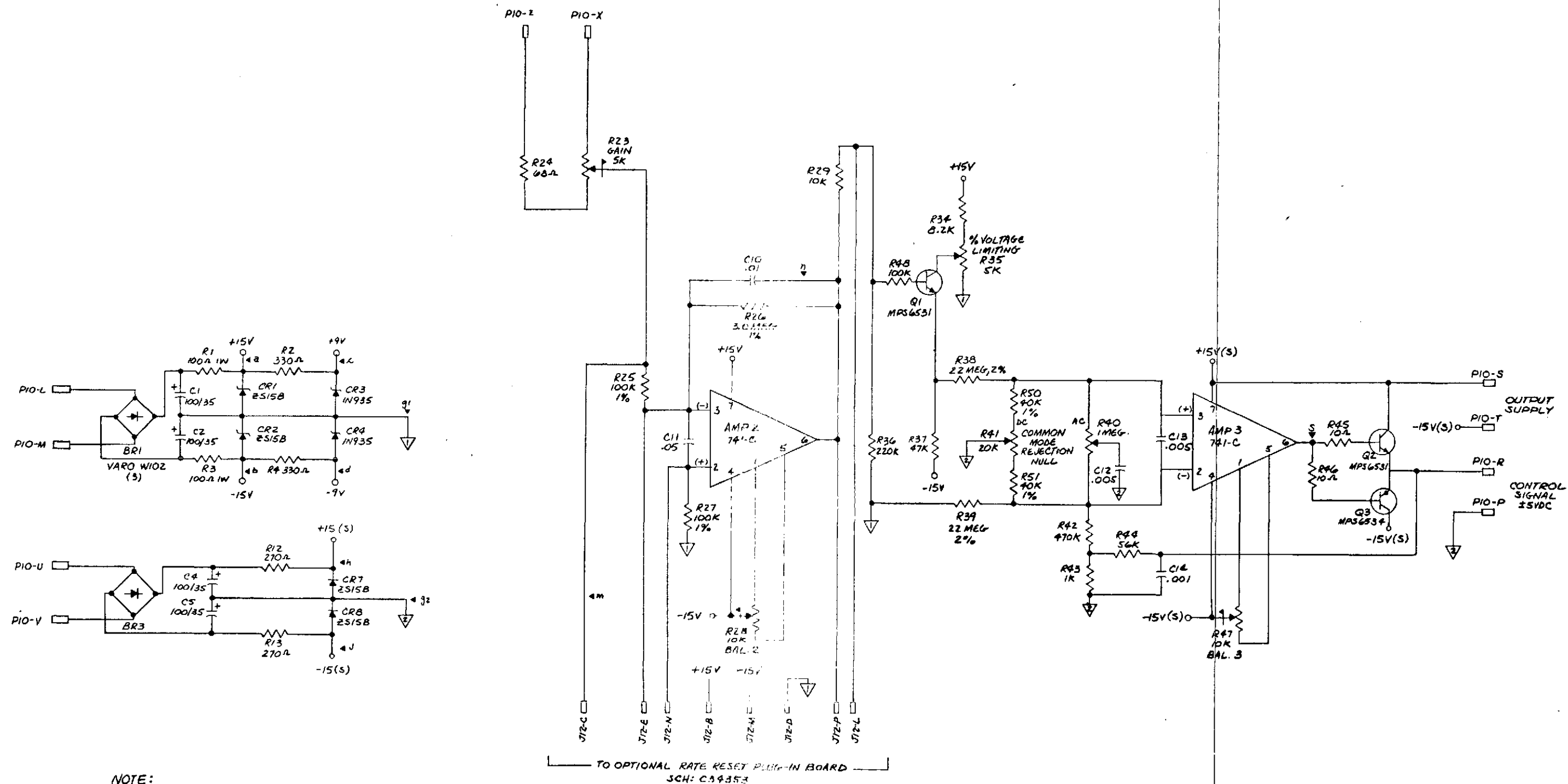


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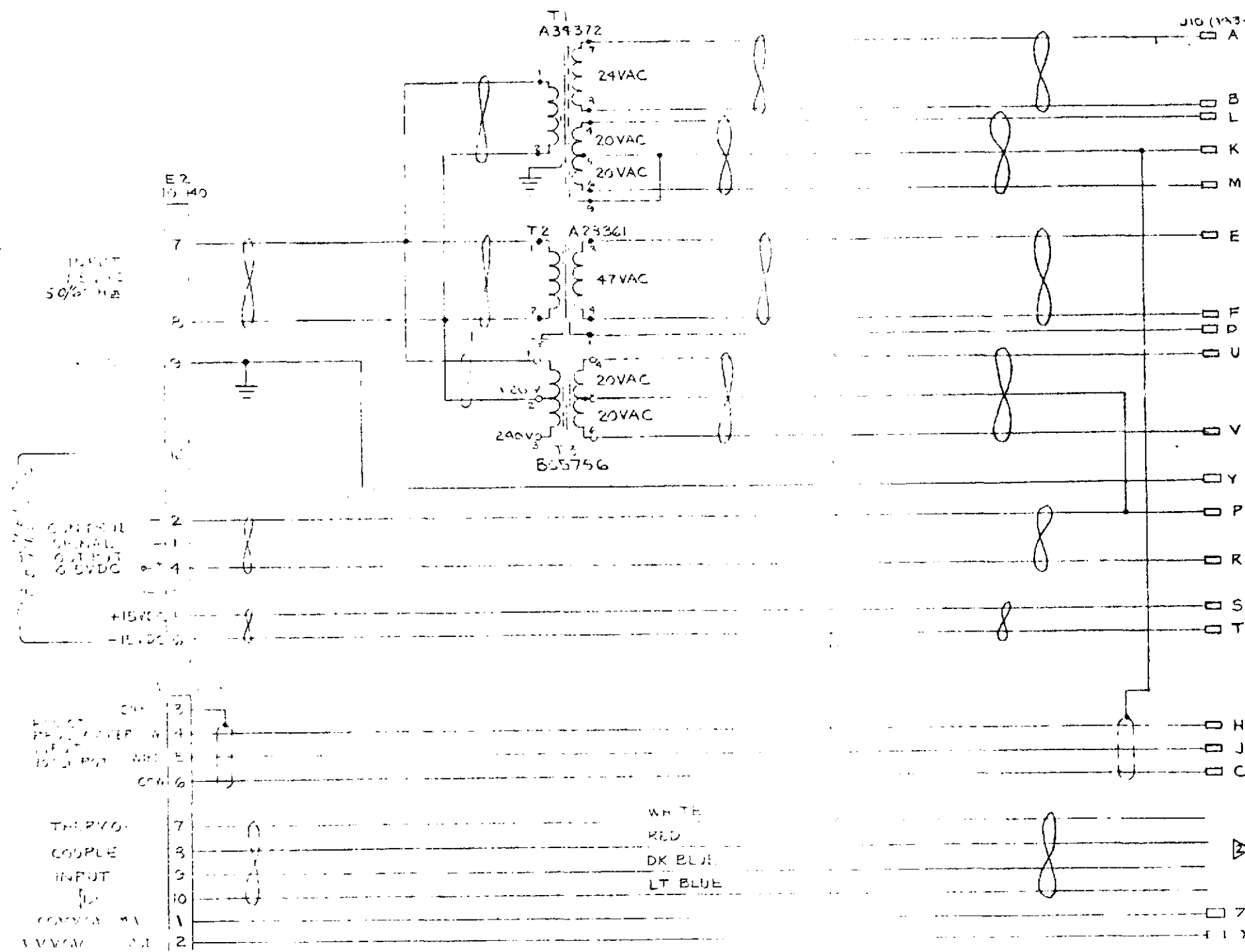


NOTE:

1. ▽ SEPERATE COMMONS BY NUMBER
2. ▼ INDICATES TEST POINT.
3. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS,  $\pm 5\%$ ,  $\frac{1}{2}W$  - CAPACITANCE IN MFD  $\pm 20\%$ .
4. SEE DWG CA1261 FOR PIO CONNECTIONS

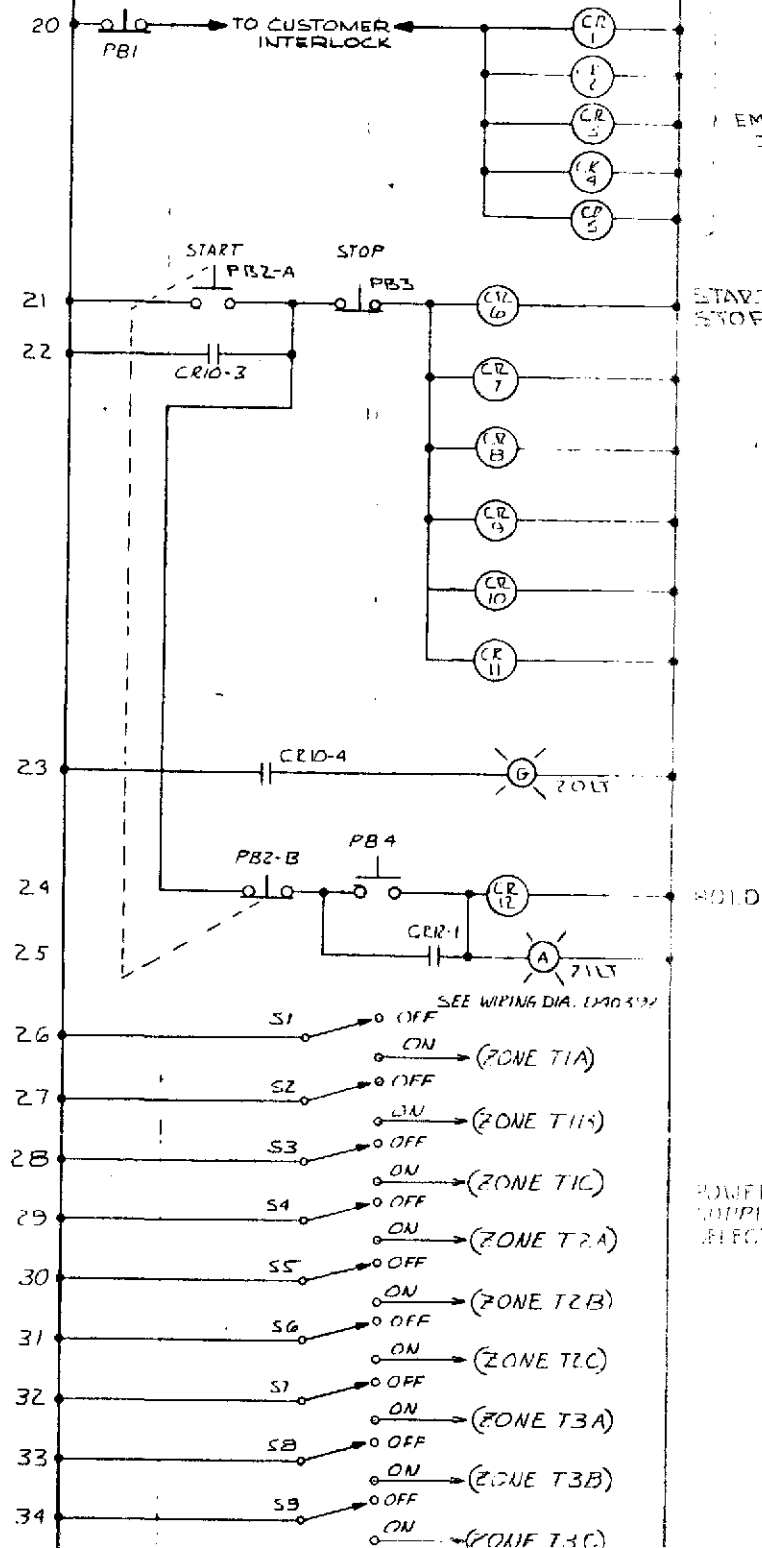
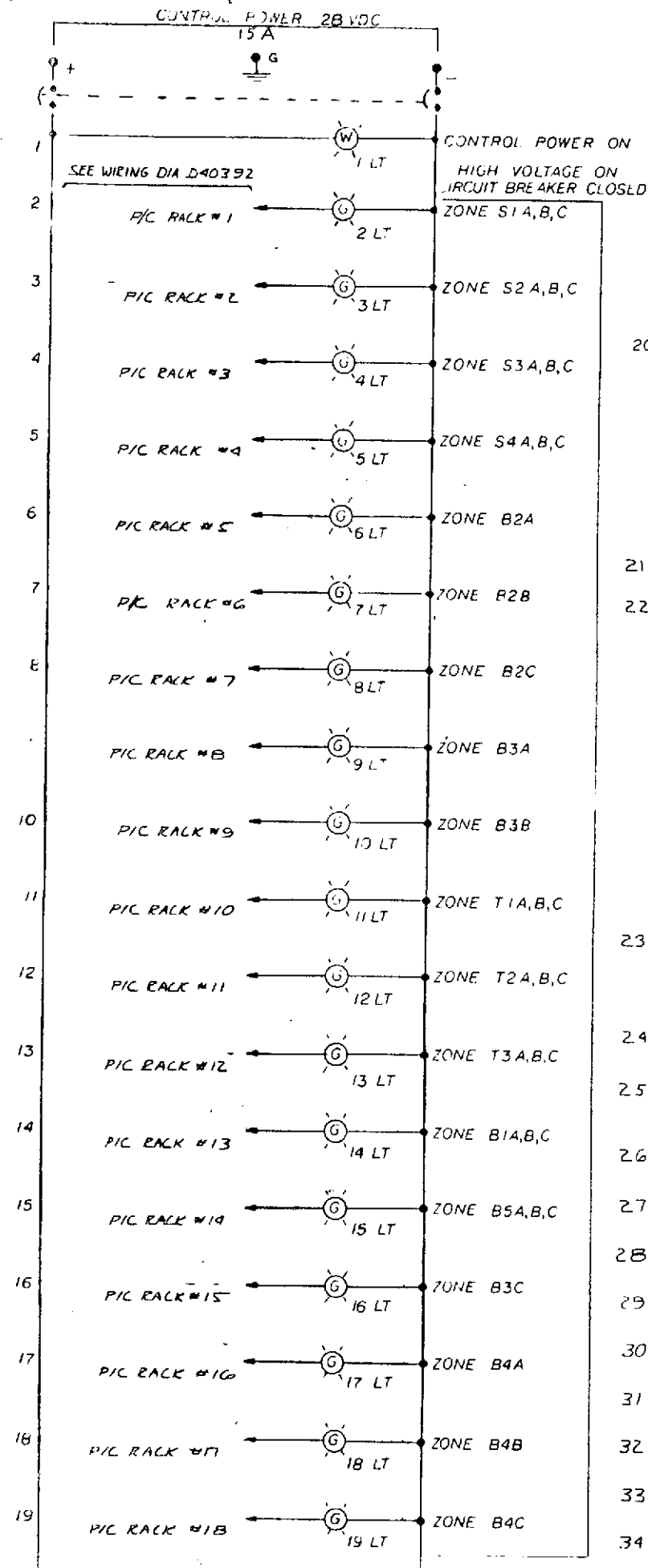
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| R-I CONTROLS                   |  |           |  |        |  |     |  |

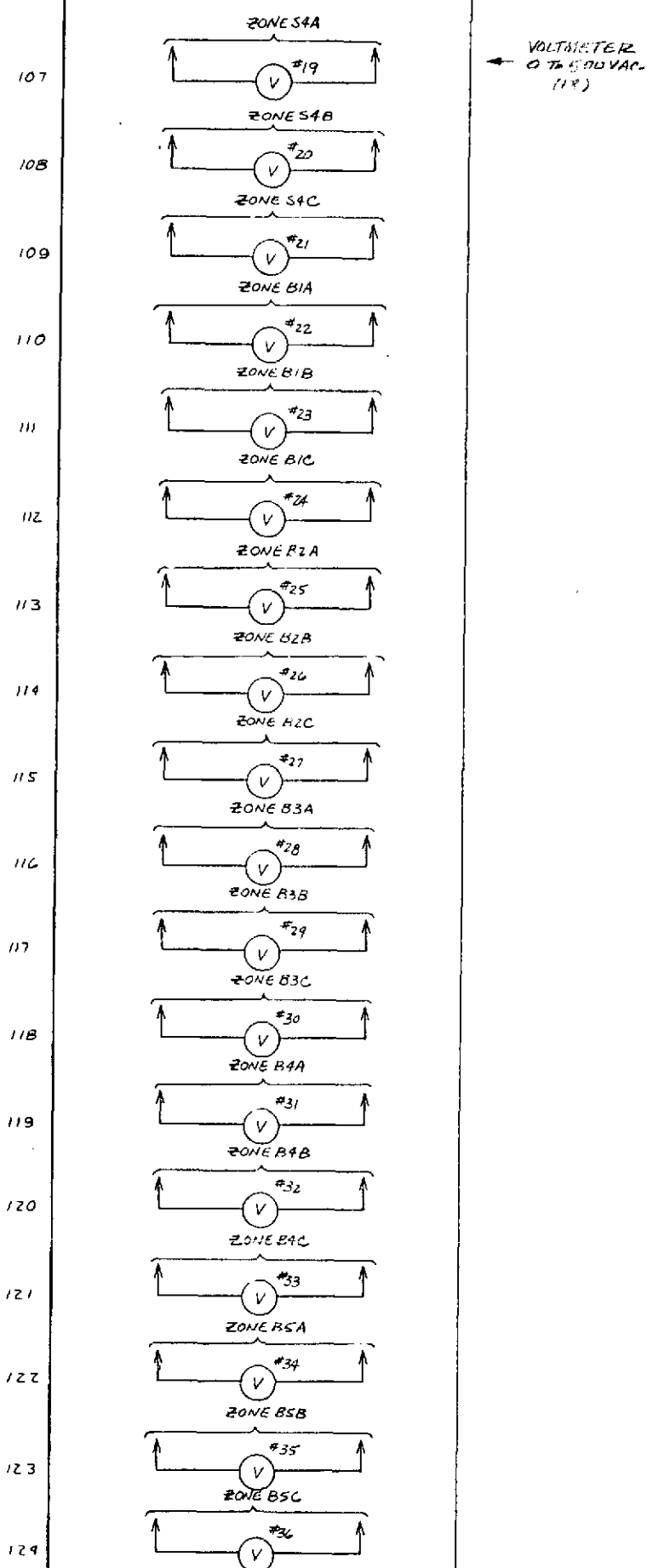
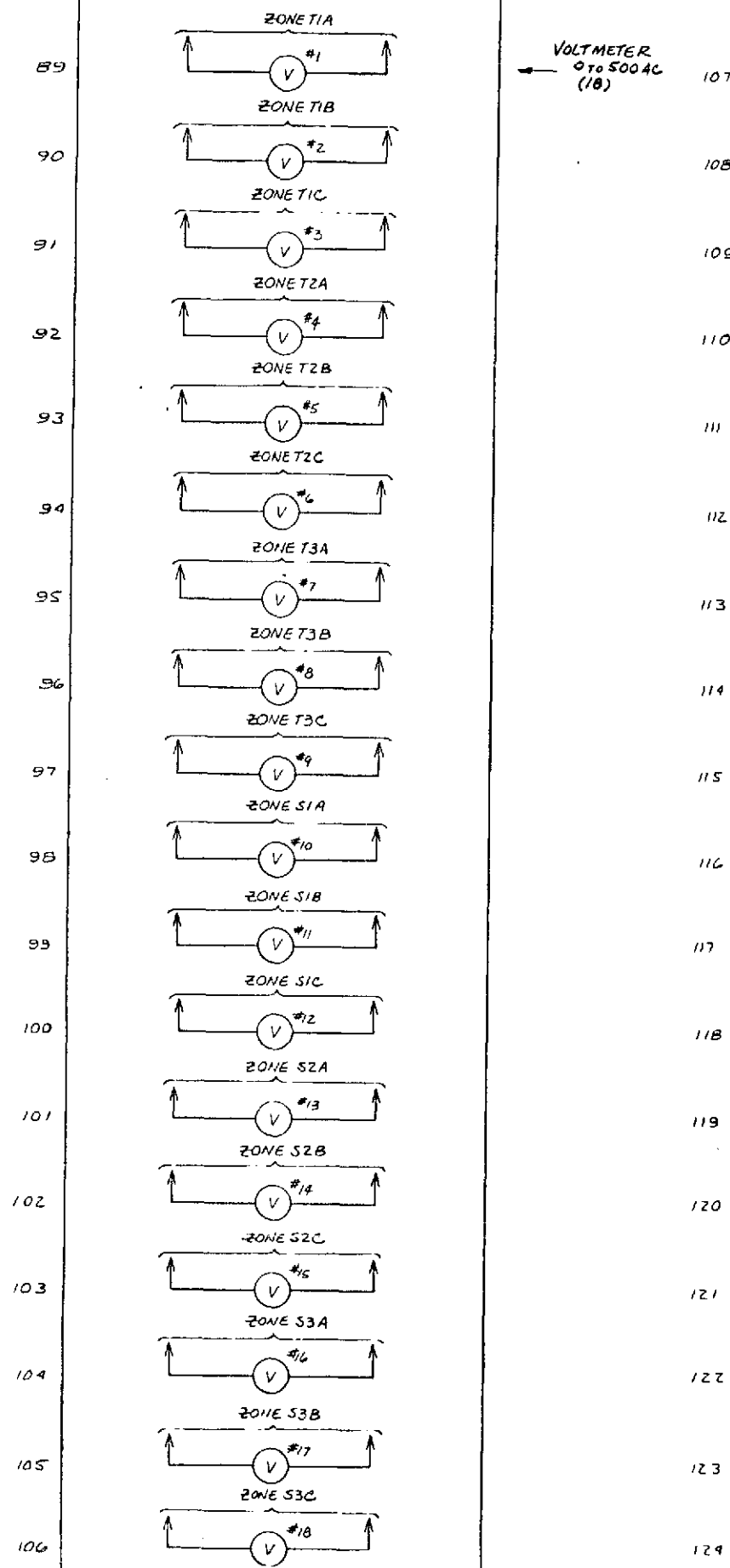


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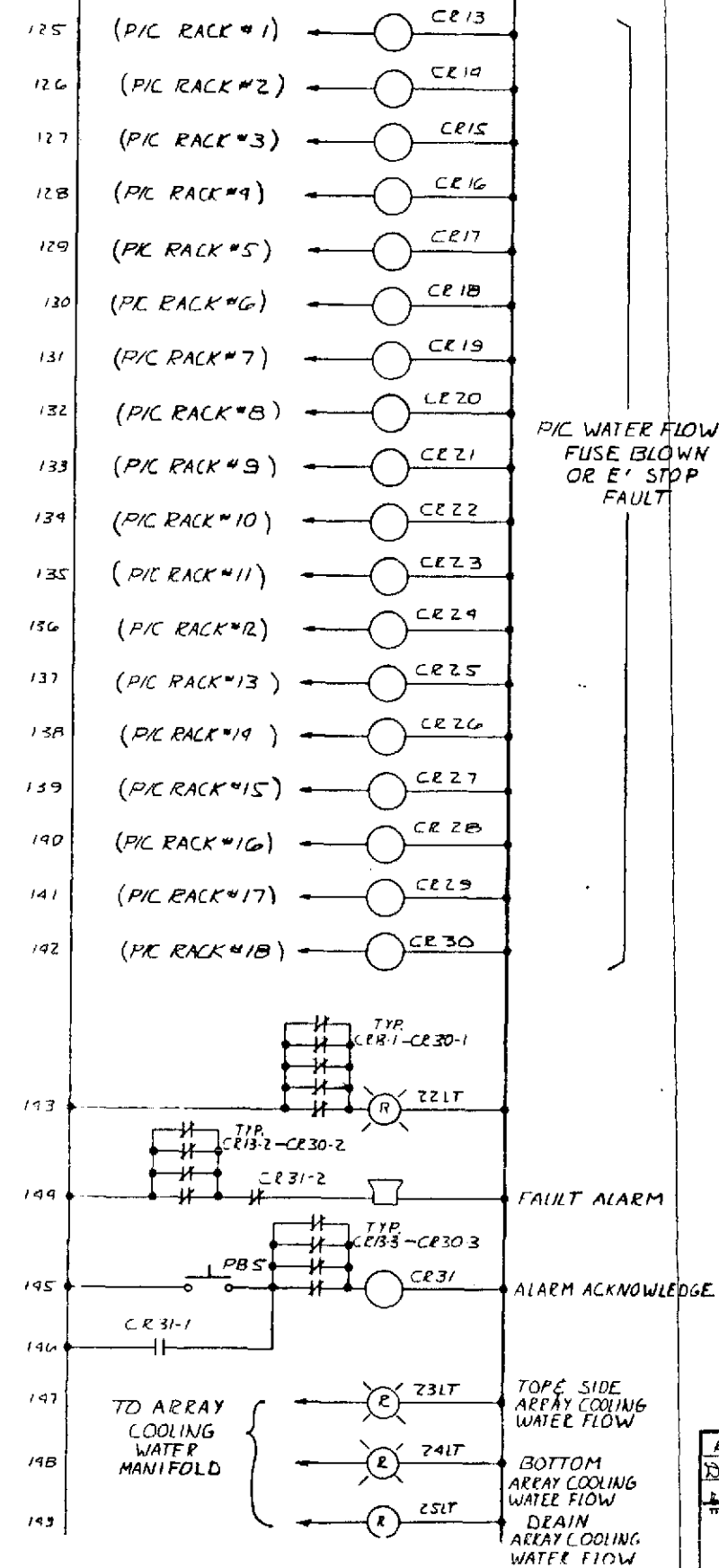
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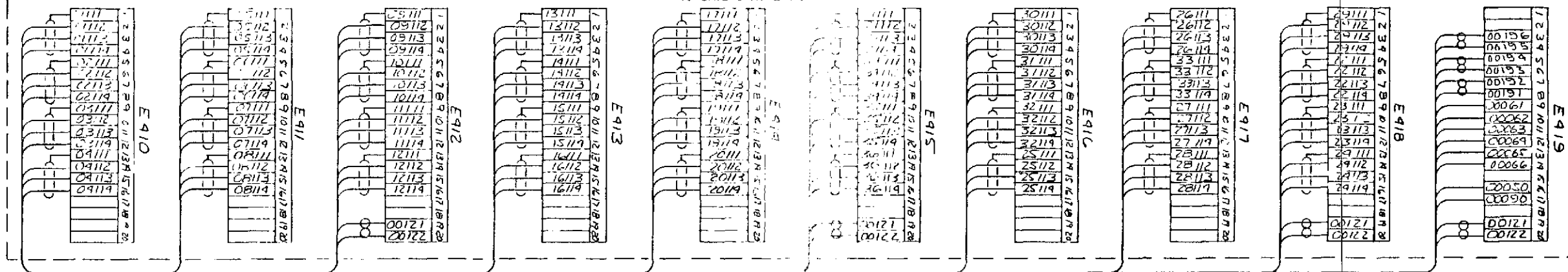
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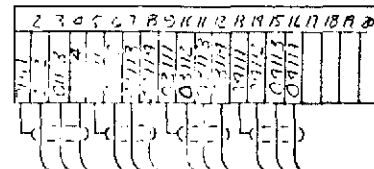
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| APPROVED<br><b>6-5 12/1/71</b>  |  | CONNECTION          |  | NO CONNECTION       |  |   |  |                         |  |                 |  |
| TITLE<br><b>ELECTRICAL FUNCTIONAL DIAGRAM<br/>28 VDC CONTROL SYSTEM<br/>THERMAL SIMULATOR</b> |  |                     |  |                     |  |   |  | NUMBER<br><b>D40391</b> |  | REV<br><b>5</b> |  |
| RESEARCH INCORPORATED   |  |                     |  |                     |  |   |  |                         |  |                 |  |

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| B         | CORRECTED NUMBERING SEQUENCE | AKS   | 2-20-72 |

PROGRAMMER & CONTROL RACK  
WIRING DIA. D41022TEMPERATURE CONTROL RACK #1  
WIRING DIA. D41022

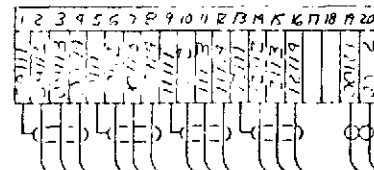
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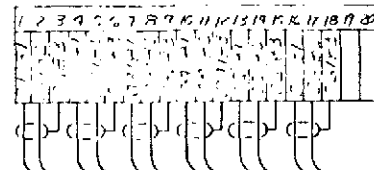
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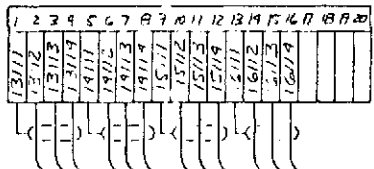
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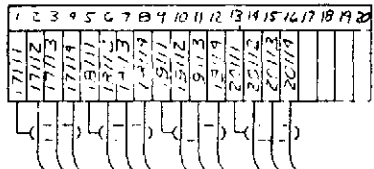
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TEMPERATURE CONTROL RACK #2  
WIRING DIA. D41023

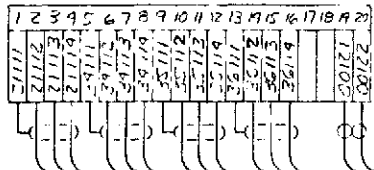
E201



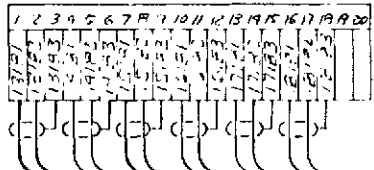
E201



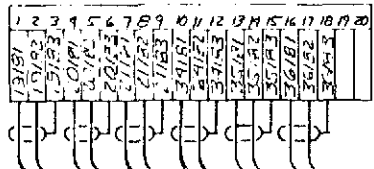
E202



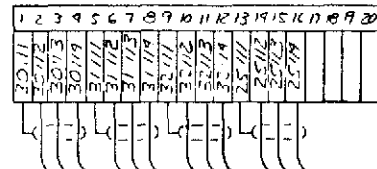
E203



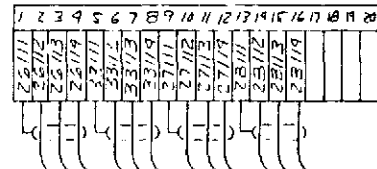
E204

TEMPERATURE CONTROL RACK #3  
WIRING DIA. D41024

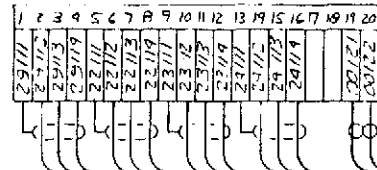
E300



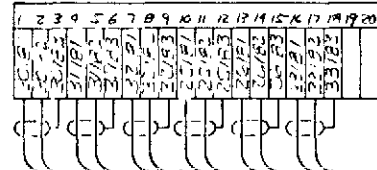
E301



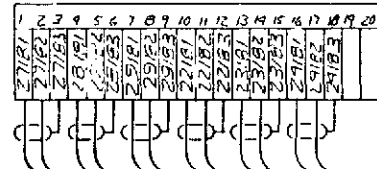
E302



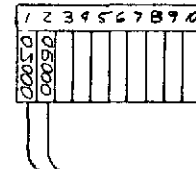
E303



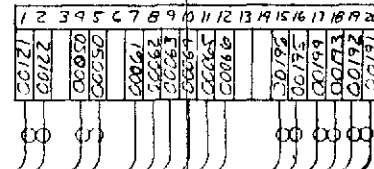
E304



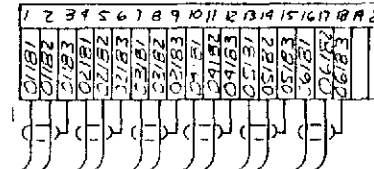
E519

POWER SUPPLY SELECT AND  
VOLTmeter RACK  
WIRING DIA. D41047COOLING GAS & WATER FLOW  
CONTROL RACK  
WIRING DIA. D41069

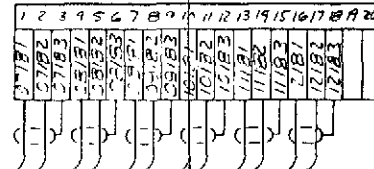
E603



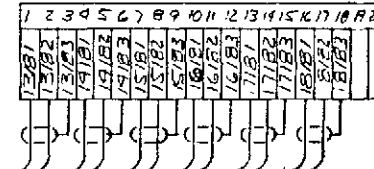
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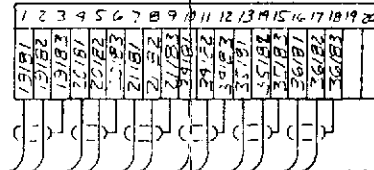
E605



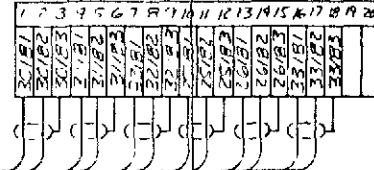
E606



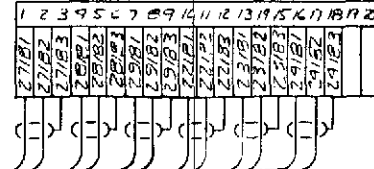
E607



E608



E609



MSFC CONTRACT NAS 8-26416

COR APPROVAL

DATE 2/2/72

|  |                           |                 |                             |   |                 |   |
|--|---------------------------|-----------------|-----------------------------|---|-----------------|---|
| DESIGNED<br>AKS<br>1-17-72   | CHECKED<br>AKS<br>1-17-72 | DATE<br>1-17-72 | CONNECTION<br>NO CONNECTION | UNLESS OTHERWISE INDICATED:<br>• RESISTANCE IN OHMS ± 10% 1/4 WATT<br>• CAPACITANCE IN PFD ± 10%<br>• INDUCTANCE IN HENRIES<br>• USE 60/40 ROBIN CORE SOLDER<br>• USE NO CORROSIVE FLUX | MODEL<br>D41152 | REV.<br>3                                       |
| WIRING DIAGRAM - INTERCONNECTION OF<br>MASTER CONTROL CONSOLE<br>(THERMAL SIMULATOR) |                           |                 |                             |   |                 | RESEARCH INCORPORATED<br>MINNEAPOLIS, MINNESOTA |

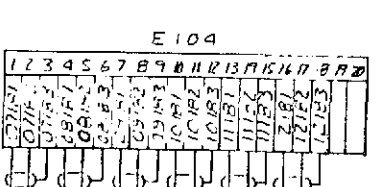
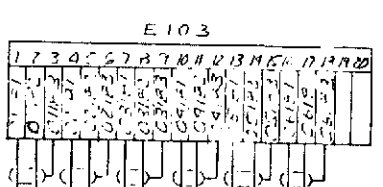
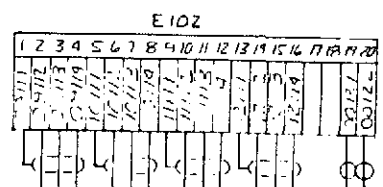
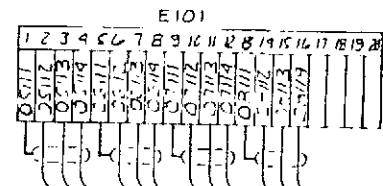
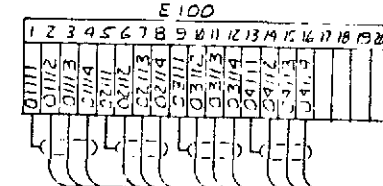
FOLDOUT FRAME

FOLDOUT FRAME

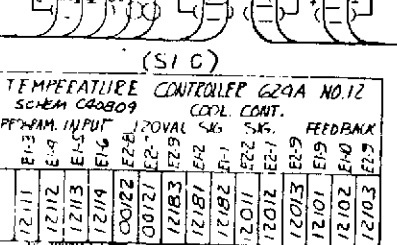
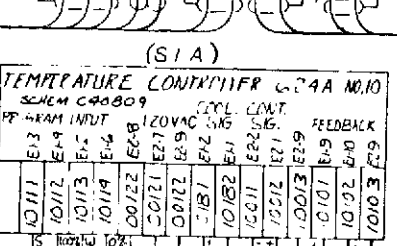
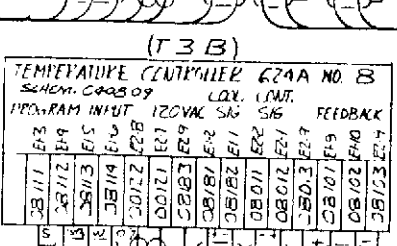
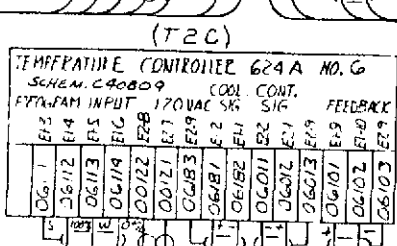
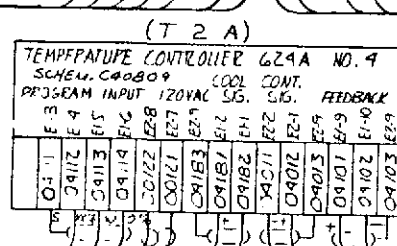
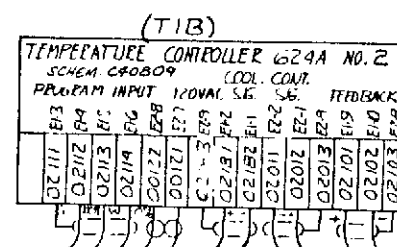
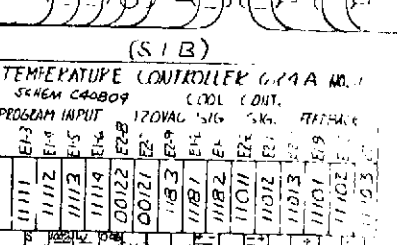
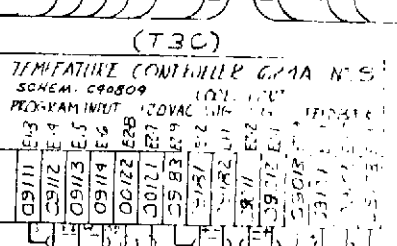
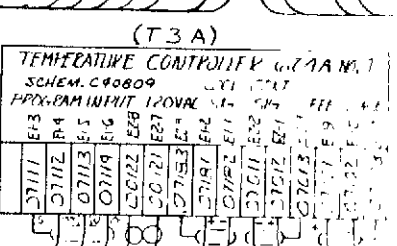
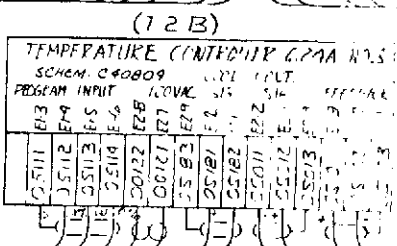
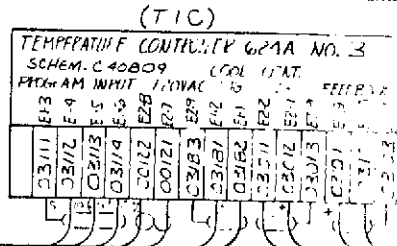
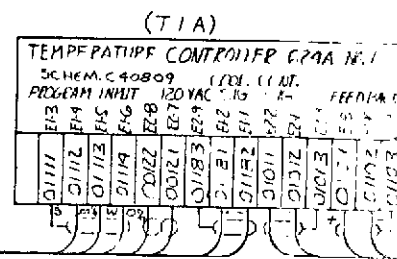
2

| REVISIONS |                       |         |     |
|-----------|-----------------------|---------|-----|
| REV.      | DESCRIPTION           | DATE    | BY  |
| A         | ADD MSFC CONTRACT NO. | 1-15-72 | AKB |
| B         | UPDATED TO AS BUILT   | 1-17-72 | PMF |

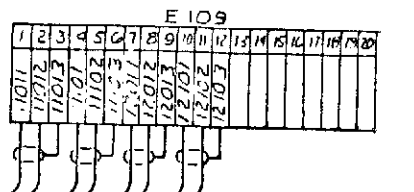
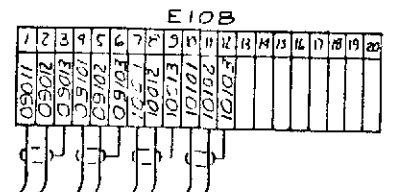
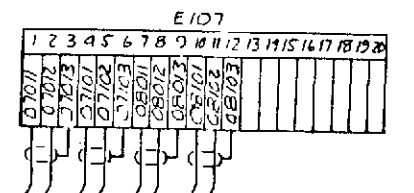
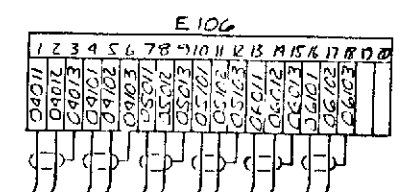
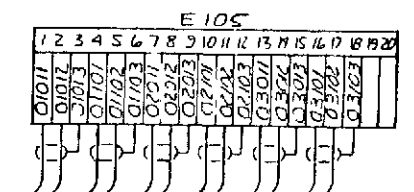
# SYSTEM INTERCONNECTION PANEL CABINET NO. 1



REF. INTERCONNECTING WIRING DIAGRAM  
D41152



# EXTERNAL INTERCONNECTION PANEL CABINET NO. 1



REF. INTERCONNECTING WIRING DIAGRAM  
D40392

MSFC CONTRACT NAS 8-26416

COR APPROVAL 1/22/72 DATE 1/22/72

|   |   |   |
|---|---|---|
| RMF 11171<br>11171<br>11171                                 | UNLESS OTHERWISE INDICATED:<br>* RESISTANCE IN OHMS & 10%<br>* CAPACITANCE IN PFD & 20%<br>* DIMENSIONS IN INCHES<br>* USE 50/50 ROBIN COSE SOLDER<br>* USE NO CORROSIVE FLUX | MODEL<br>D41072                                 |
| WIRING DIAGRAM - TEMPERATURE CONTROL<br>(THERMAL SIMULATOR) |   | RESEARCH INCORPORATED<br>MINNEAPOLIS, MINNESOTA |



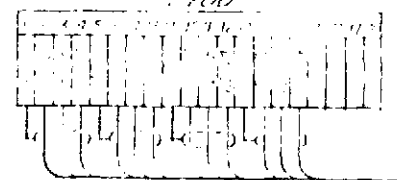
FOLDOUT FRAME

FOLDOUT FRAME

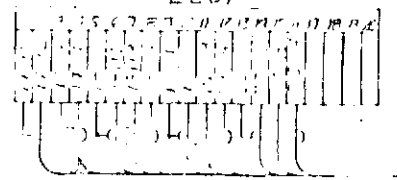
2

| REVISIONS |                       |
|-----------|-----------------------|
| NO.       | DESCRIPTION           |
| A         | ADD MSFC CONTRACT NO. |
| B         | UPDATED TO DATA SHEET |

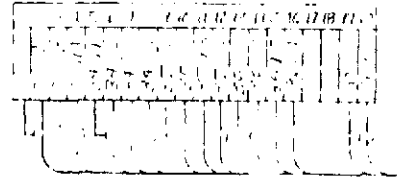
SYSTEM INTERCONNECTION PANEL  
CABINET NO. 2



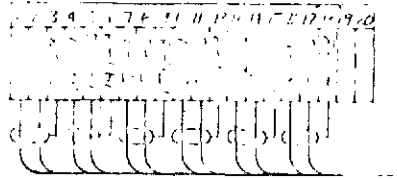
E201



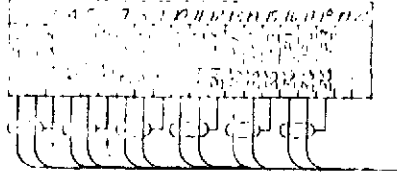
E202



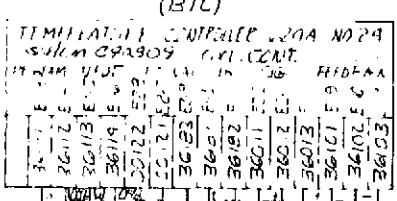
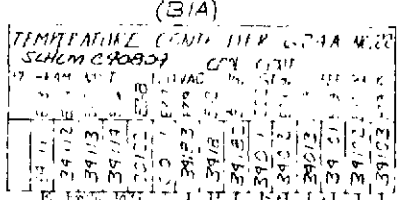
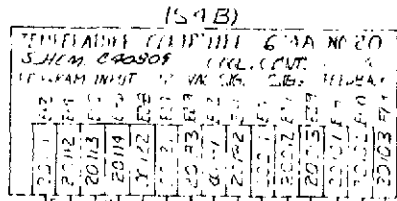
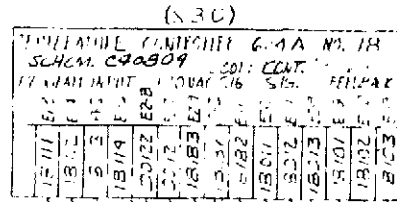
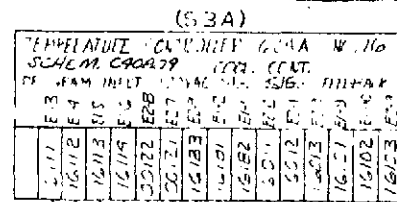
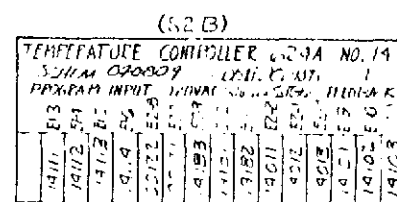
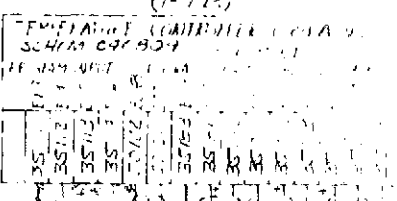
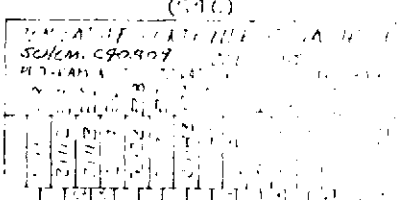
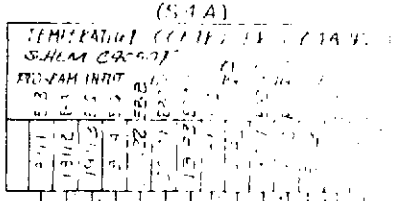
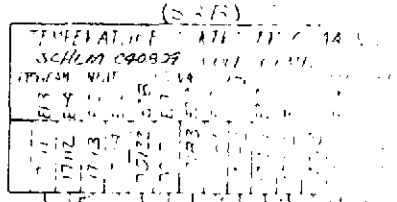
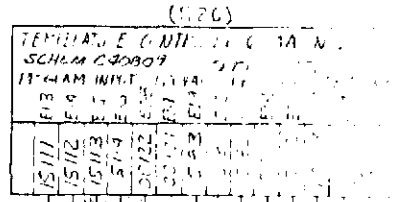
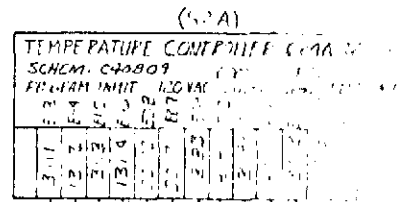
E203



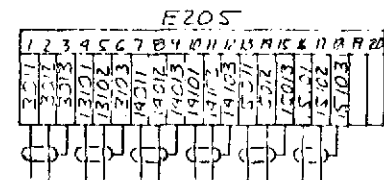
E204



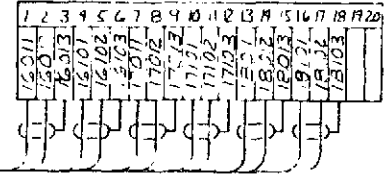
REF. INTERCONNECTING WIRING DIAGRAM  
040392



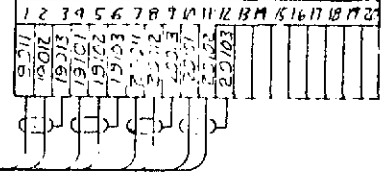
EXTERNAL INTERCONNECTION PANEL  
CABINET NO. 2



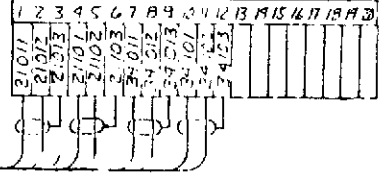
E205



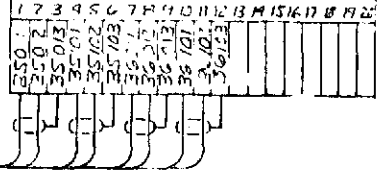
E206



E207



E208



E209



REF. INTERCONNECTING WIRING DIAGRAM  
040392

MSFC CONTRACT NAS 8-26416

COR APPROVAL DATE

|  |  |               |
|--|--|---------------|
| DRAFTSMAN<br>K.M. HUNN<br>CHECKED<br>K.M. HUNN<br>DATE<br>11-22-77       | UNLESS OTHERWISE INDICATED:<br>* RESISTANCE IN OHMS ± 10% 1/4 WATT<br>* CAPACITANCE IN PFD ± 20%<br>* INDUCTANCE IN HENRIES<br>* USE SOLDERED CORE BOLDER<br>* SEE NO CORROSIVE FLUX | MODEL<br>1073 |
| WIRING DIAGRAM - TEMPERATURE CONTROLLER<br>BACK # 2<br>INITIAL SIMULATOR |  |               |
| RESEARCH INCORPORATED WINNEAPOLIS, MINNESOTA                             |  |               |

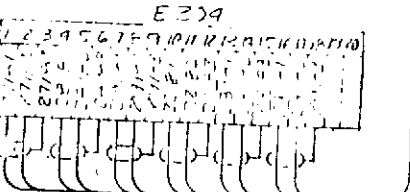
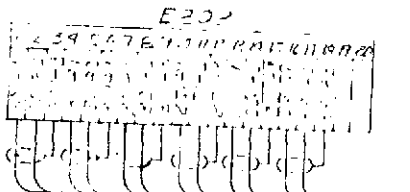
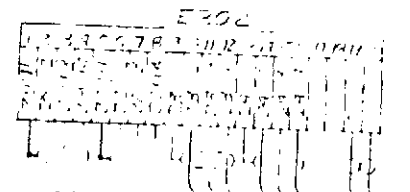
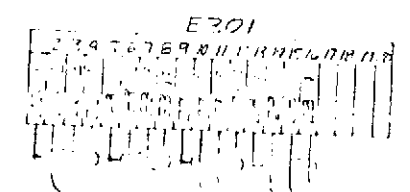
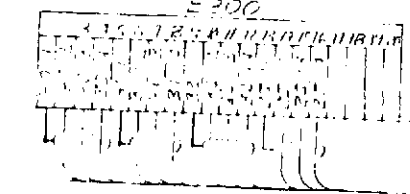
FOLDOUT FRAME

FOLDOUT FRAME

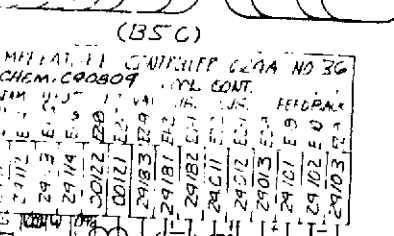
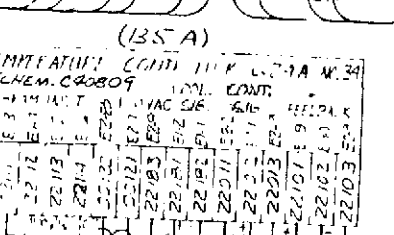
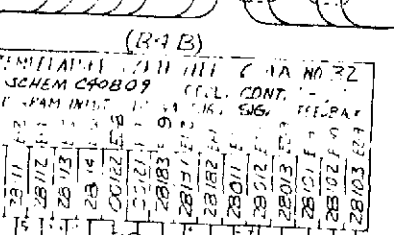
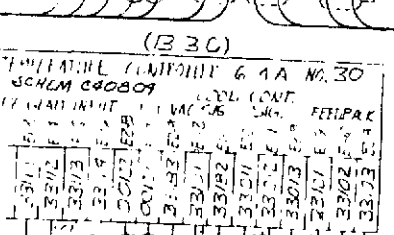
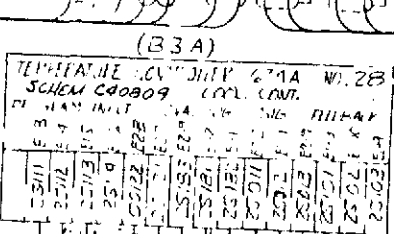
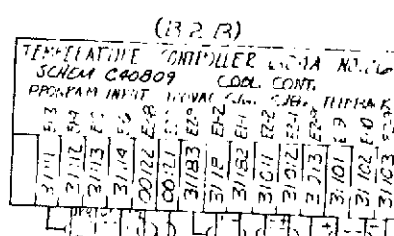
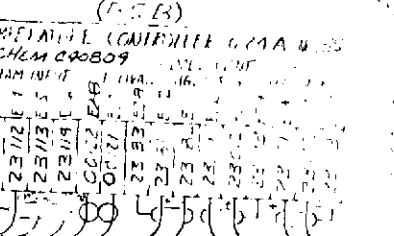
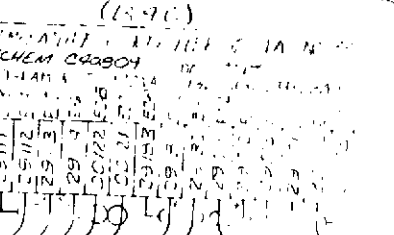
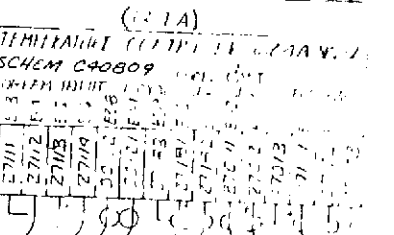
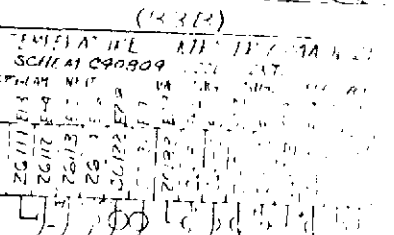
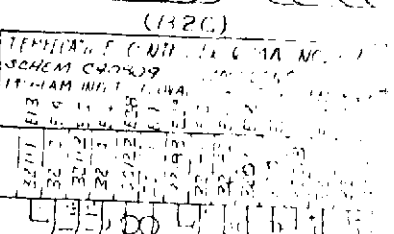
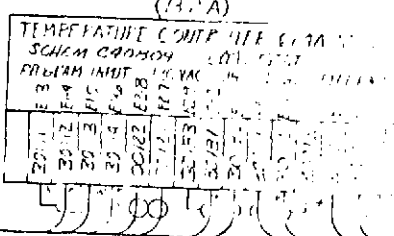
2

| REVISIONS |                                   |
|-----------|-----------------------------------|
| REV       | DESCRIPTION                       |
| A         | ADD MSFC CONTRACT NO. NAS 8-26416 |
| B         | UPDATE TO NAS 8-26416             |

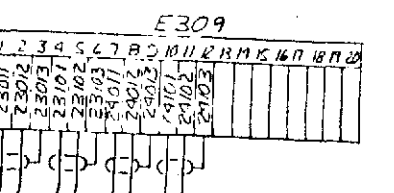
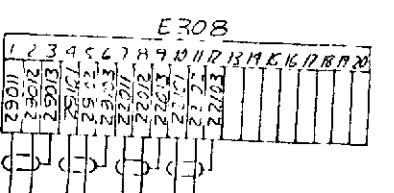
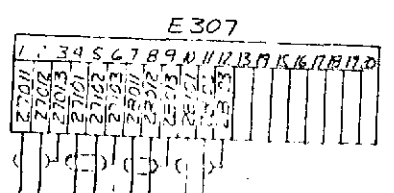
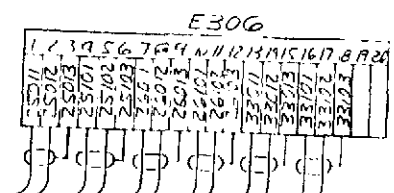
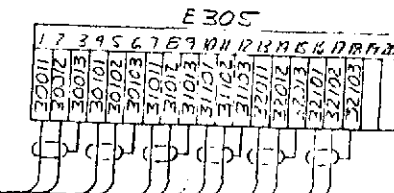
SYSTEM INTERCONNECTION PANEL  
CABINET NO. 3



SEE INTERCONNECTING WIRING DIAGRAM  
D-41152



EXTERNAL INTERCONNECTION PANEL  
CABINET NO. 3



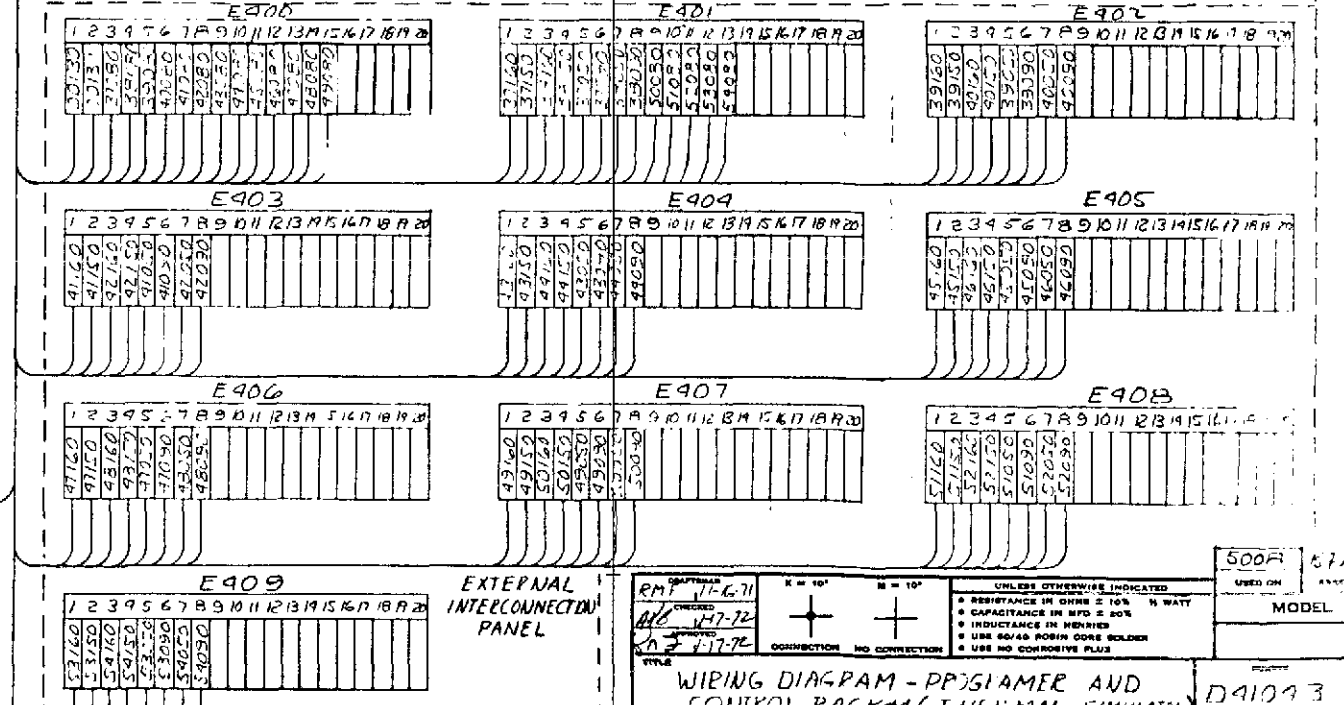
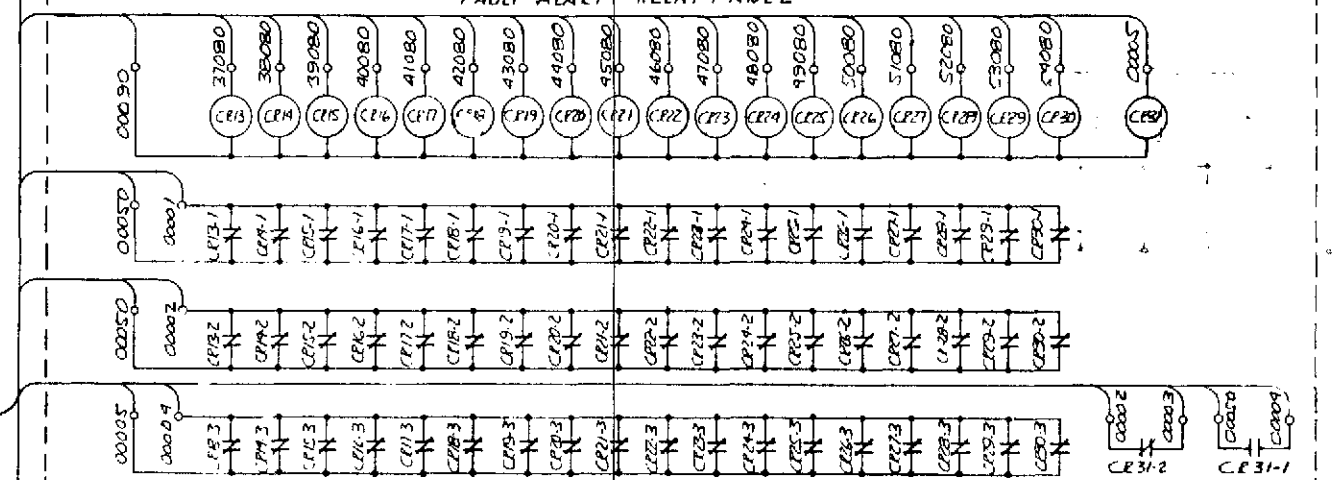
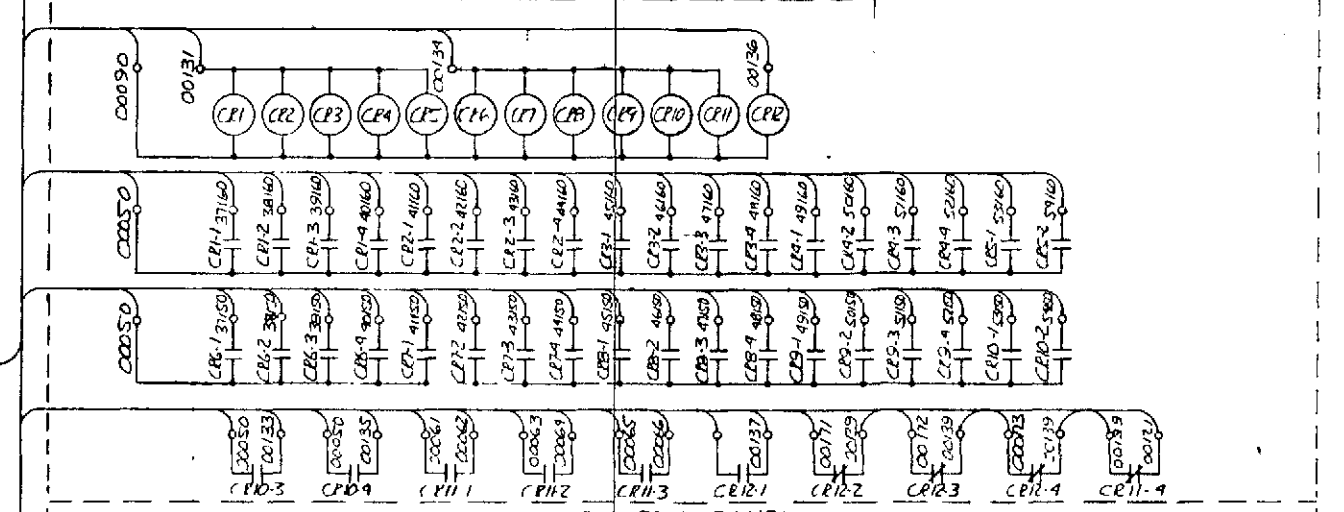
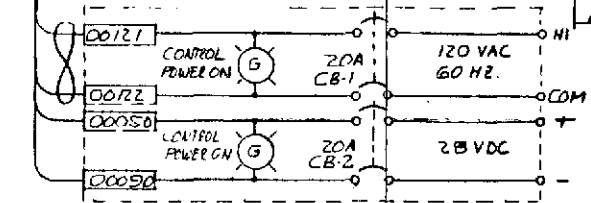
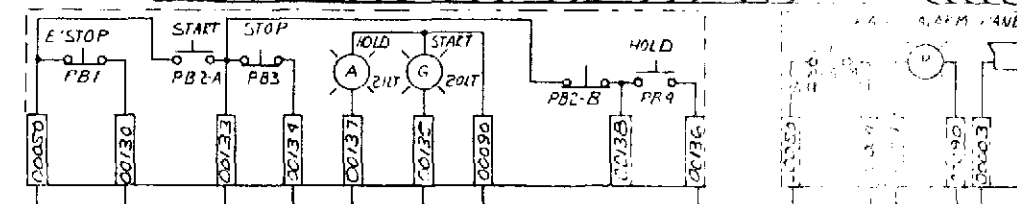
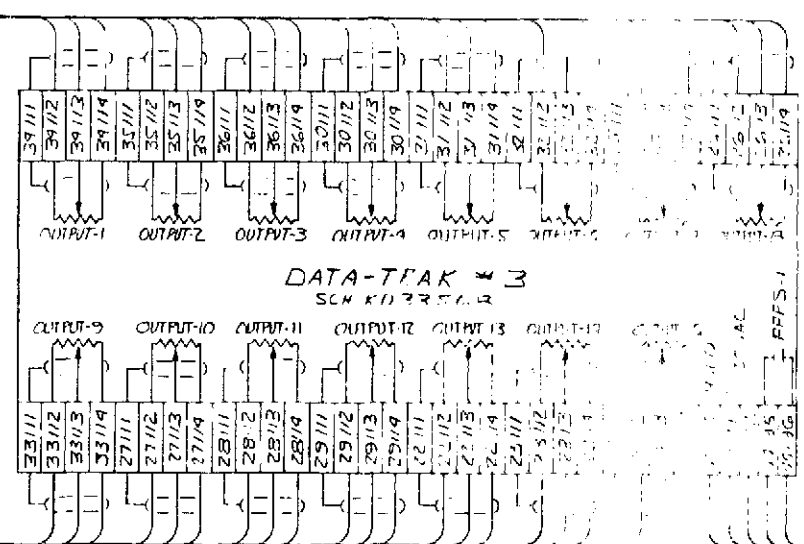
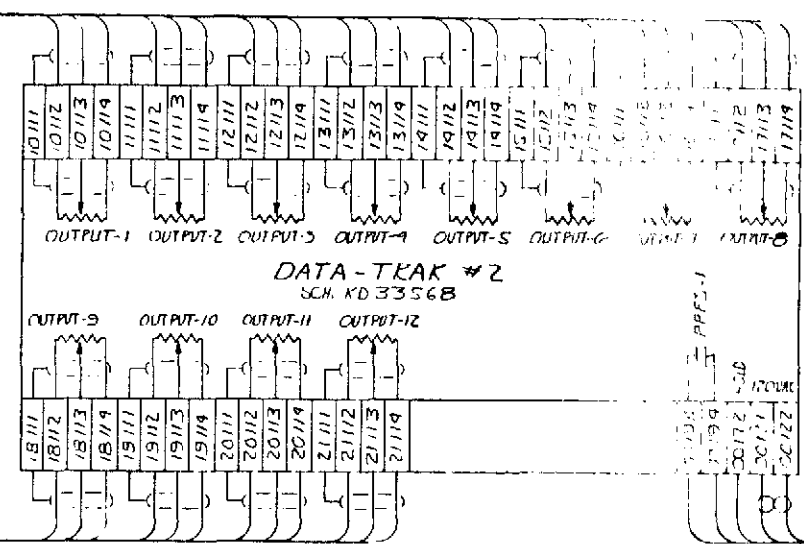
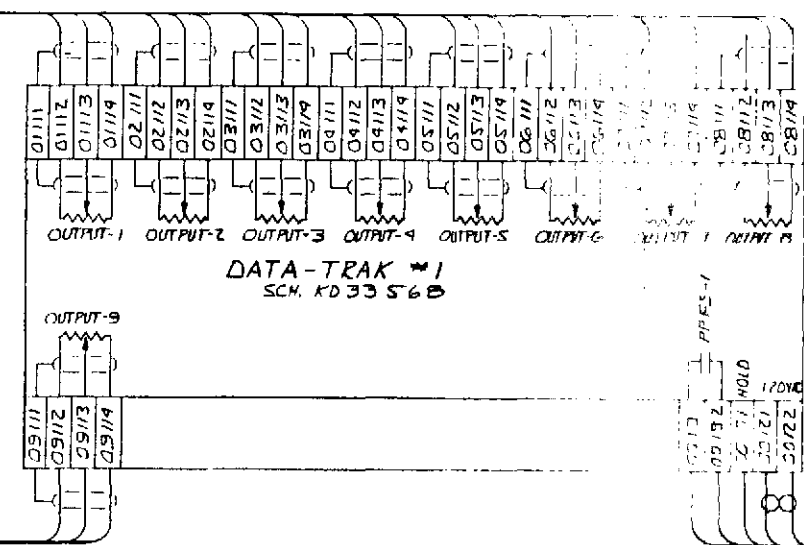
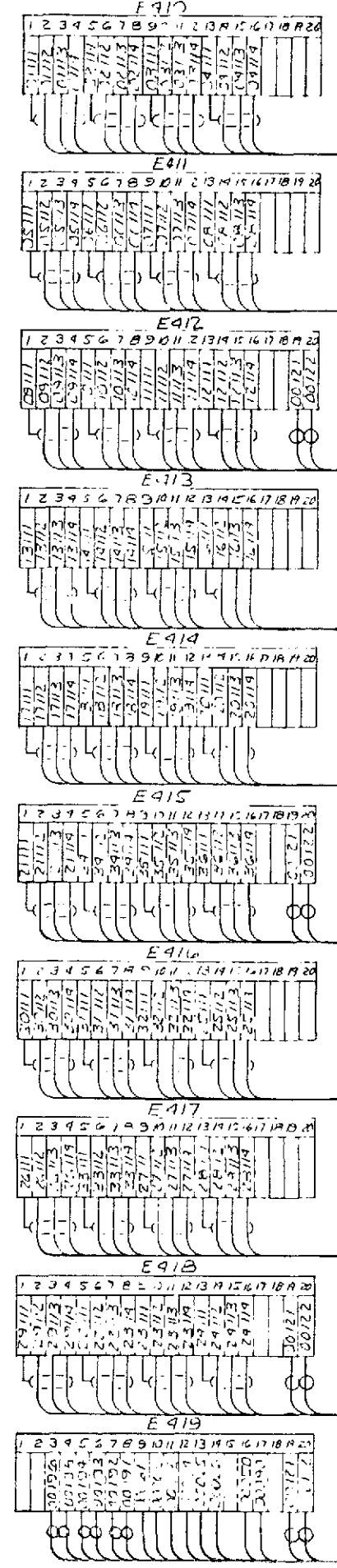
SEE INTERCONNECTING WIRING DIAGRAM  
D-41152

MSFC CONTRACT NAS 8-26416

COR APPROVAL DATE

|   |          |          |          |
|---|----------|----------|----------|
| DATE  | 11/11/72 | BY       | 11/11/72 |
| CHECKED   | 11/11/72 | APPROVED | 11/11/72 |
| UNLESS OTHERWISE INDICATED:<br>• RESISTANCE IN OHMS ± 5%<br>• CAPACITANCE IN PFD ± 5%<br>• INDUCTANCE IN HENRIES<br>• USE 60/40 ROHSIN CORE SOLDER<br>• USE NO CORROSIVE FLUX |          |          |          |
| TITLE: OPINS (A-CAM) - TEMPERATURE CONTROL<br>PAGE: 1<br>THERMAL SIMULATOR  |          |          |          |
| RESEARCH INCORPORATED<br>MINNEAPOLIS, MINNESOTA   |          |          |          |

SYSTEM INTERCONNECTION PANEL



REVISIONS

| REV. | DESCRIPTION                                | DATE    |
|------|--|---------|
| 1    | ADD MSFC CONTRACT NO. REVISED PER CKIC OUT | 1-14-72 |

MSFC CONTRACT NAS 8-26416  
COR APPROVAL *[Signature]* DATE 4/8/72

WIRING DIAGRAM - PROGRAMMER AND CONTROL PACK #4 (THERMAL SIMULATED)

RESEARCH INCORPORATED MINNEAPOLIS, MINNESOTA

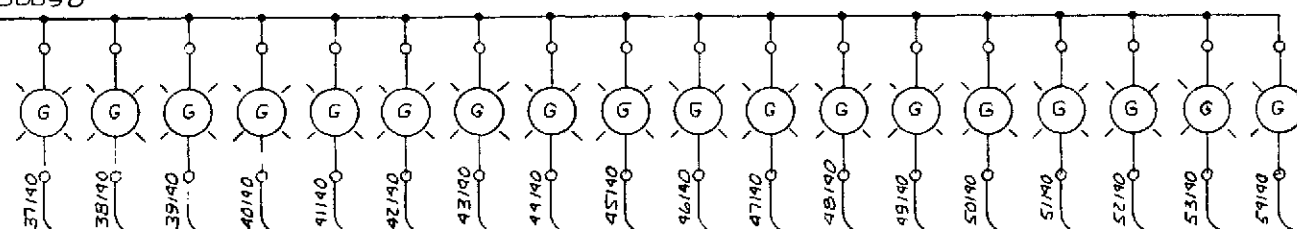
| REVISIONS |                              |       |         |
|-----------|------------------------------|-------|---------|
| REV.      | DESCRIPTION                  | DRAFT | DATE    |
| A         | ADD MSFC CONTRACT NO.        | AKC   | 1-19-72 |
| B         | VOLT METER SCHEM NAS: B57771 | EF    | 1-19-72 |

E519

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 50053 | 50054 | 50055 | 50056 | 50057 | 50058 | 50059 | 50060 | 50061 | 50062 |

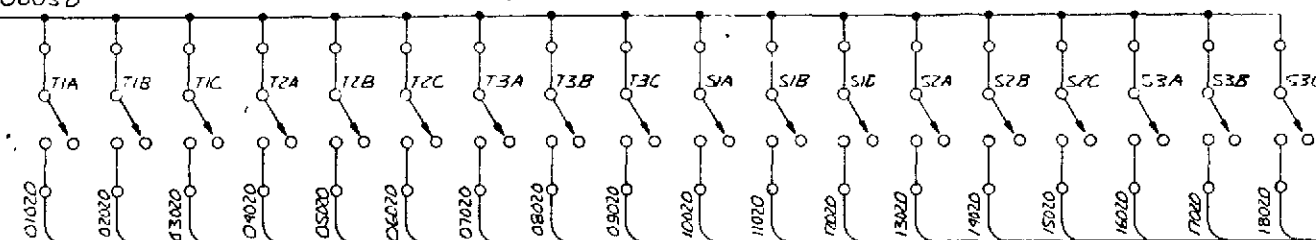
00090

POWER ON LITES RACK 1-1B

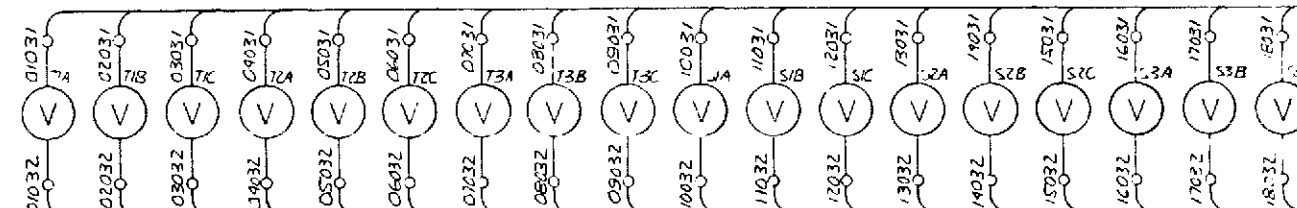
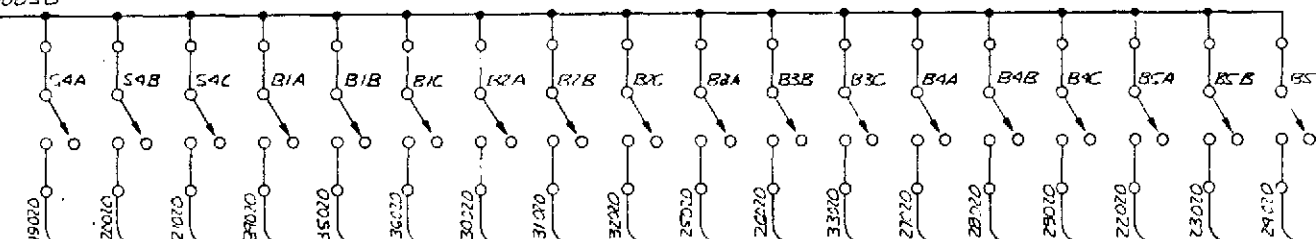
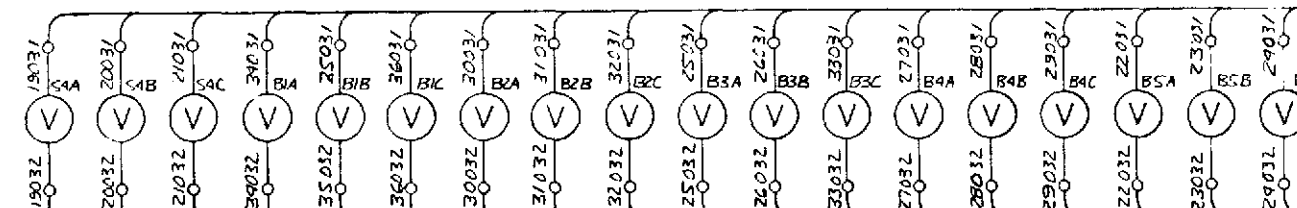


00050

POWER SUPPLY SELECT SWITCHES



00050

FOR VOLT METER RACK 1-1B  
REF. SCH. B-01452FOR VOLT METER RACK 1-1B  
REF. SCH. B-01452EXTERNAL CONNECTION PANEL  
REF. SCH. D-40392

E500

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 37140 | 38140 | 39140 | 40140 | 41140 | 42140 | 43140 | 44140 | 45140 | 46140 |

E501

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 47140 | 48140 | 49140 | 50140 | 51140 | 52140 | 53140 | 54140 | 55140 | 56140 |

E502

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 02010 | 02020 | 03020 | 04020 | 05020 | 06020 | 07020 | 08020 | 09020 | 10020 |

E503

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 12011 | 12021 | 13021 | 14021 | 15021 | 16021 | 17021 | 18021 | 19021 | 20021 |

E504

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 02012 | 02022 | 03022 | 04022 | 05022 | 06022 | 07022 | 08022 | 09022 | 10022 |

E505

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 02012 | 02022 | 03022 | 04022 | 05022 | 06022 | 07022 | 08022 | 09022 | 10022 |

E506

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E507

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E508

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E509

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E510

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E511

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E512

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

E513

|       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| 1E010 | 1E020 | 1E030 | 1E040 | 1E050 | 1E060 | 1E070 | 1E080 | 1E090 | 1E100 |

MSFC CONTRACT NAS 8-26416

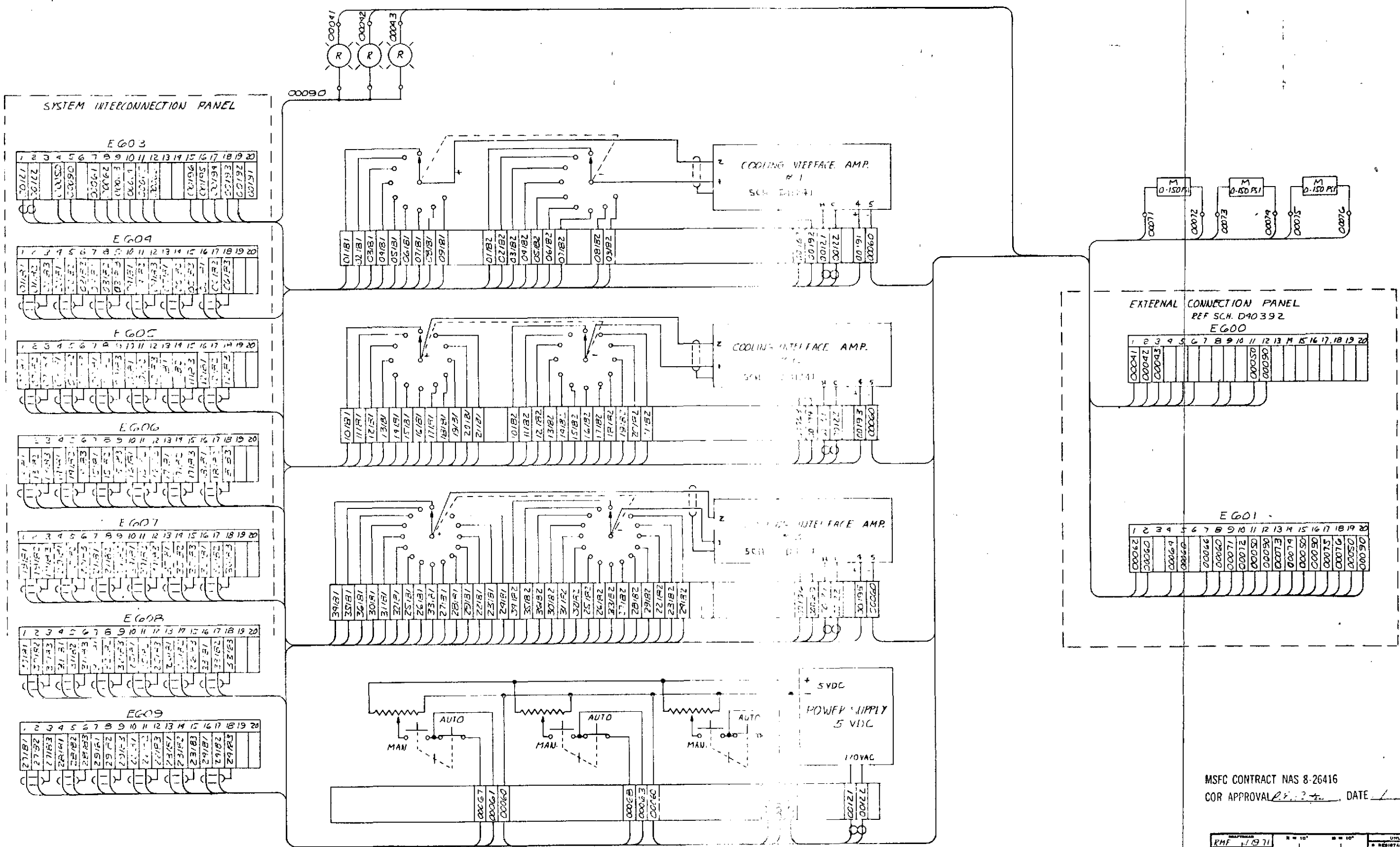
CON. APPROVAL 25-200 DATE 2/1/72

|   |                 |                        |   |
|---|-----------------|------------------------|---|
| DATE: 11-17-71  | BY: [Signature] | REVISION: 1            | DESCRIPTION: WIRING DIAGRAM - POWER SUPPLY SELECT & VOLTMETER RACK #5 (THERMAL SIMULATOR) |
| TITLE: WIRING DIAGRAM - POWER SUPPLY SELECT & VOLTMETER RACK #5 (THERMAL SIMULATOR) |                 | MODEL: D41047          |   |
| RESEARCH INCORPORATED   |                 | MINNEAPOLIS, MINNESOTA |   |

FOLDOUT FRAME

FOLDOUT FRAME

| REVISIONS |                           |       |          |
|-----------|---------------------------|-------|----------|
| REV.      | DESCRIPTION               | DRAWN | DATE     |
| A         | ADDED DETAILS TO COOL AMP | AKB   | 12-14-77 |
| B         | ADD MSFC CONTRACT NO.     | AKB   | 1-14-77  |



MSFC CONTRACT NAS 8-26416  
COR APPROVAL 2-1-78 DATE 1-14-77

|   |                              |                 |                    |            |
|---|------------------------------|-----------------|--------------------|------------|
| DESIGNED BY<br>RHF<br>1/19/77                                       | CHECKED BY<br>AKB<br>1/17/78 | DATE<br>1-14-77 | UNIT NO.<br>491064 | MODEL<br>P |
| WIRING DIAGRAM COOLING GAS & WATER FLOW RACK #6 (THERMAL SIMULATOR) |                              |                 |                    |            |
| RESEARCH INCORPORATED MINNEAPOLIS, MINNESOTA                        |                              |                 |                    |            |

A DIVERSITY OF RESEARCH PROGRAMS  
MINNEAPOLIS, MINNESOTA 55455

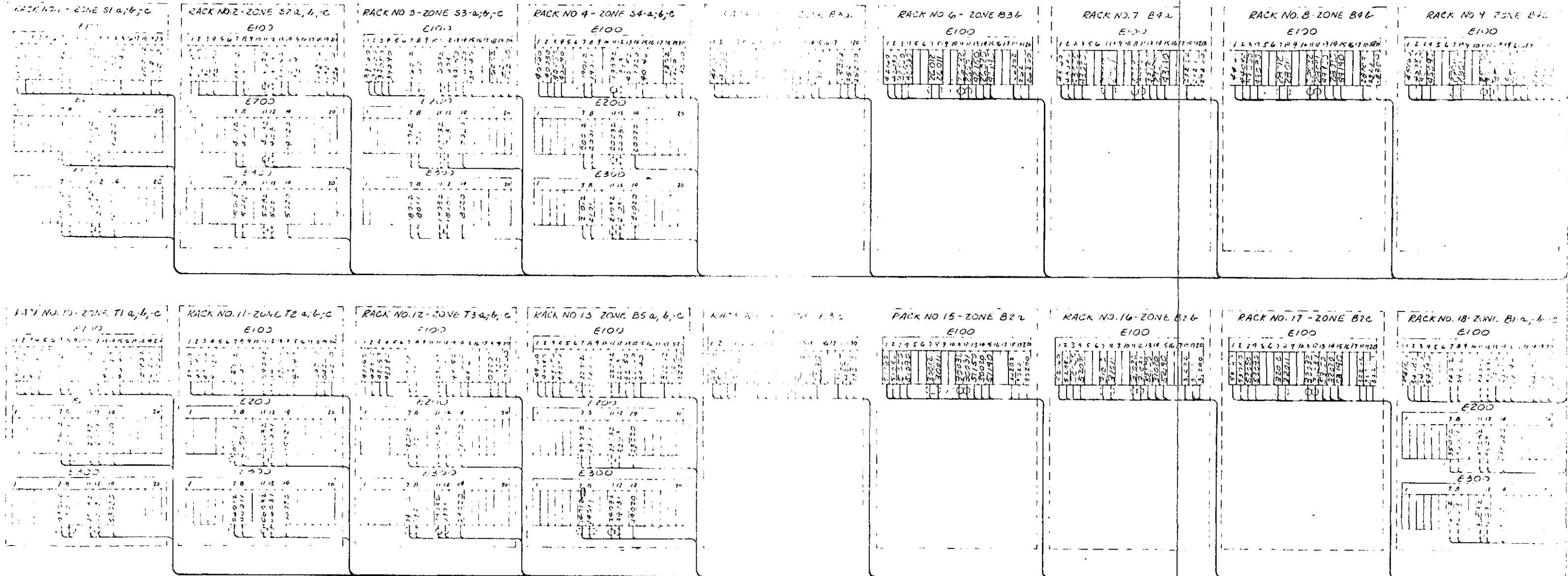


## FOLDOUT FRAME

2

| REVISIONS |                                 |
|-----------|---------------------------------|
| BY        | DESCRIPTION                     |
| A         | ADD MSFC CONTRACT NO.           |
| B         | CHANGED TO "ITEM WITH TACTICAL" |
| C         | REMOVED TERMINAL "A.A.A."       |
| D         | CORRECTED "EXACTLY" ENTER       |

5



1. D442L CDD = SHIELDED WIRES  
D442L OO = TWISTED PAIR

2. LEFT TO DAY NO D44392 - F. IN WIRE AND FUNCTION

COR APPROVAL 12/1/81, DATE 12/1/81

|                               |  |                            |  |  |  |  |  |                                      |  |
|-------------------------------|--|----------------------------|--|--|--|--|--|--------------------------------------|--|
| PART NUMBER<br><b>67-1-27</b> |  | MATERIAL<br><b>67-1-27</b> |  | INVENTORY<br>1 PLACE DEL<br>2 PLACE DEL<br>3 |  | NEW OR<br>REPAIR<br>REPAIR<br>REPAIR     |  | PLANT<br>PLANT<br>PLANT              |  |
| QUANTITY<br><b>1</b>          |  | UNIT<br><b>1</b>           |  | REMARKS<br><b>INTERCONNECT- WIRING</b>       |  | INVENTORY<br><b>INTERCONNECT- WIRING</b> |  | PLANT<br><b>INTERCONNECT- WIRING</b> |  |
| DATE<br><b>1-27-67</b>        |  | TIME<br><b>1-27-67</b>     |  | REMARKS<br><b>POWER CONTROLLER</b>           |  | INVENTORY<br><b>POWER CONTROLLER</b>     |  | PLANT<br><b>POWER CONTROLLER</b>     |  |

FOLDOUT FRAME

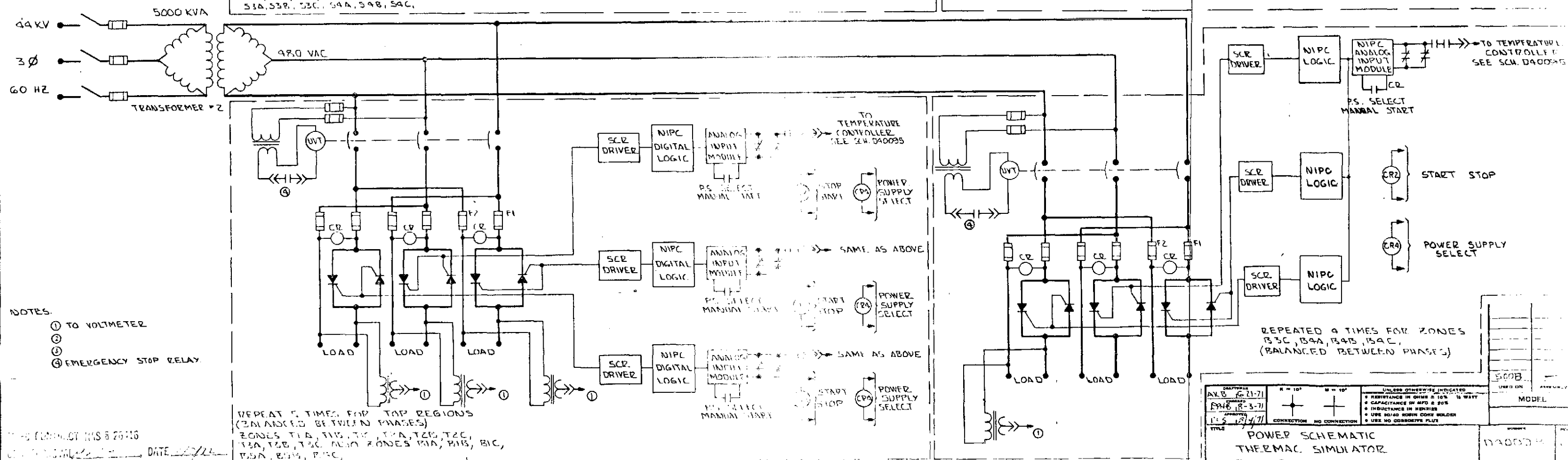
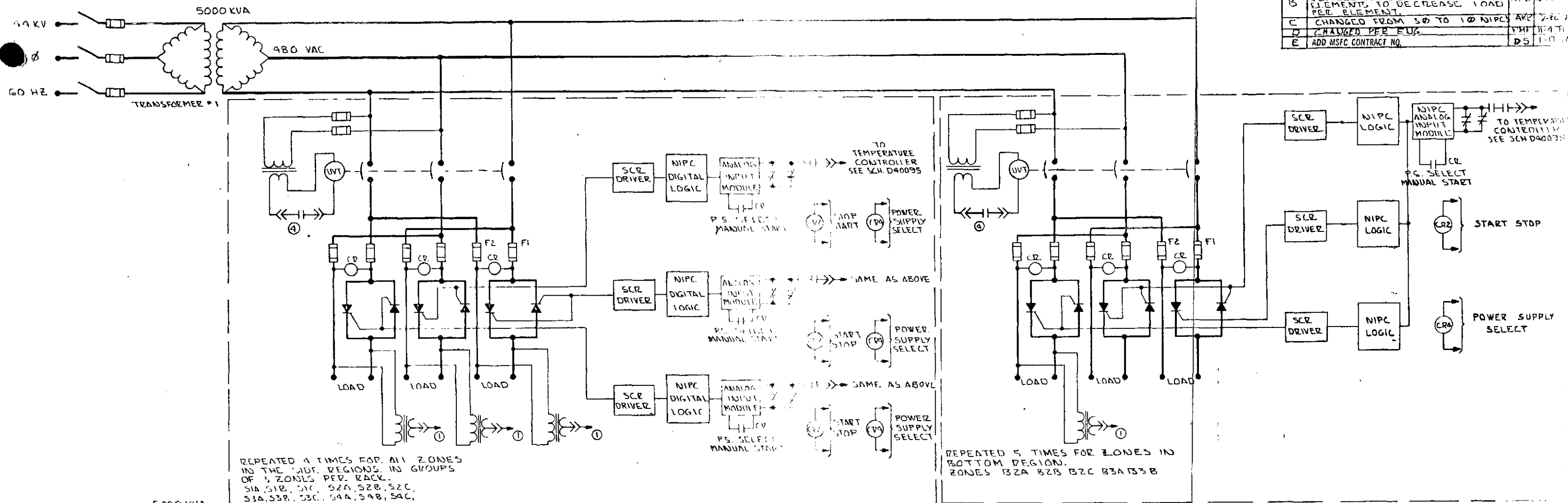
| REVISIONS |                         |       |         |
|-----------|-------------------------|-------|---------|
| SYM.      | DESCRIPTION             | DRAFT | DATE    |
| A         | END WORK ON PROJECT NO. |       |         |
| B         | SEE SHEET 1             | YMF   | 2-10-71 |
| C         | SEE SHEET 1             | KMF   | 2-10-71 |
| D         | SEE SHEET 1             | KMF   | 9-10-72 |

TO  
SHEET 1.

CC - [unclear] P.E. [unclear] DATE 2/8/72

[illegible]

| REVISIONS |   |             |     |
|-----------|---|-------------|-----|
| REV.      | DESCRIPTION   | DATE        | BY  |
| B         | DELETED POWER CONTROL ELEMENTS TO DECREASE LOAD PER ELEMENT | APR 21 1971 | AVC |
| C         | CHANGED FROM 50 TO 10 NIPES                                 | APR 21 1971 | AVC |
| D         | CHANGED PER EUB   | APR 21 1971 | AVC |
| E         | ADD MSFC CONTRACT NO.                                       | APR 21 1971 | AVC |

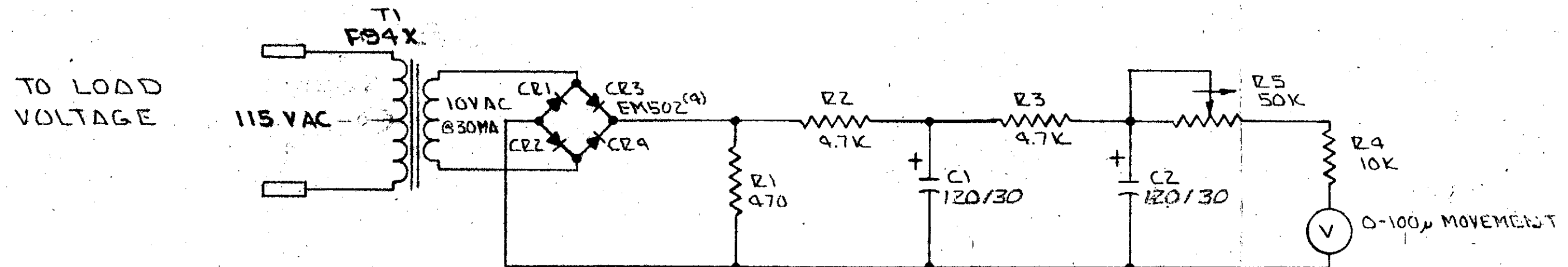


- NOTES:
- ① TO VOLTMETER
  - ②
  - ③
  - ④ EMERGENCY STOP RELAY

|   |                   |           |                             |   |
|---|-------------------|-----------|-----------------------------|---|
| DESIGNER<br>AVC 6-21-71                       | DATE<br>APR 18-71 | REV.<br>1 | CONNECTION<br>NO CONNECTION | UNLESS OTHERWISE INDICATED:<br>* RESISTANCE IN OHMS & 10%<br>* CAPACITANCE IN MFD & 50%<br>* INDUCTANCE IN HENRIES<br>* USE SOLID SCREW CORE BOLDS<br>* USE NO CORROSIVE FLUX |
| TITLE<br>POWER SCHEMATIC<br>THERMAC SIMULATOR |                   |           |                             | MODEL<br>13000  |
| RESEARCH INCORPORATED MINNEAPOLIS, MINNESOTA  |                   |           |                             |   |

## REVISIONS

| SYM | ZONE | DESCRIPTION            | DRAFT | CHECK | DATE    |
|-----|------|------------------------|-------|-------|---------|
| A   |      | CHANGED C1,2 TO 120/30 | RWF   |       | 2-18-72 |

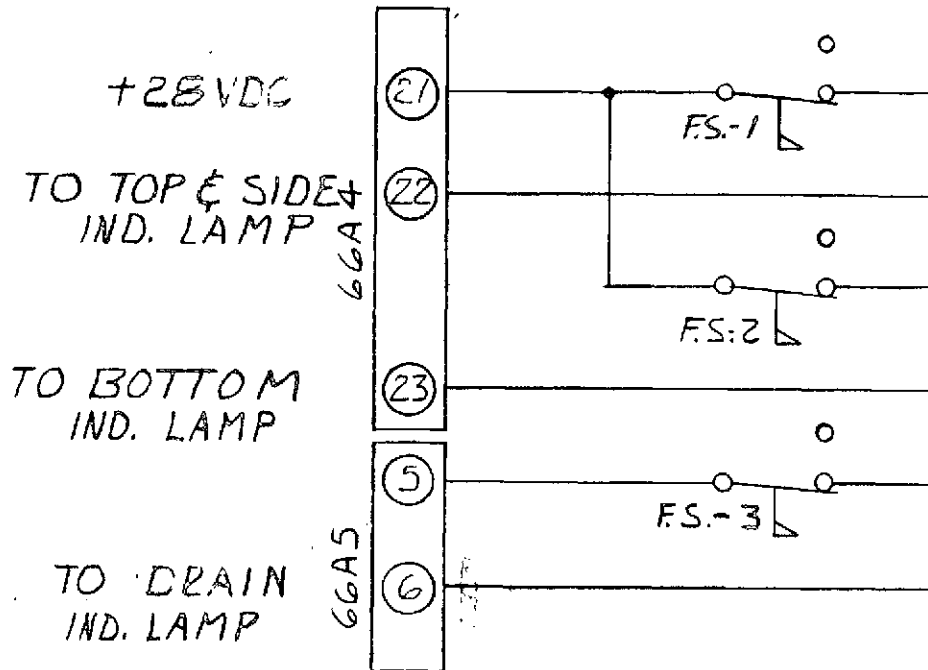


MSFC CONTRACT NAS 8-26416

COR APPROVAL \_\_\_\_\_ DATE \_\_\_\_\_

|   |  |                          |                     |   |     |
|---|--|--------------------------|---------------------|---|-----|
| CRAFTSMAN<br>AKB 11-1-71  |  | K = 10 <sup>3</sup>      | M = 10 <sup>6</sup> | UNLESS OTHERWISE INDICATED              |     |
| CHECKED   |  | +                        |                     | • RESISTANCE IN OHMS $\pm$ 10% 1/2 WATT |     |
| APPROVED<br>MADE 11-1-71  |  | +                        |                     | • CAPACITANCE IN MFD $\pm$ 20%          |     |
|   |  | CONNECTION NO CONNECTION |                     | • INDUCTANCE IN HENRIES                 |     |
| TITLE   |  |                          |                     | • USE 80/40 ROSIN CORE SOLDER           |     |
| SCHEMATIC - AVERAGING VOLTMETER CIRCUIT                               |  |                          |                     | • USE NO CORROSIVE FLUX                 |     |
|   |  |                          |                     | NUMBER                                  | REV |
|   |  |                          |                     | B41452                                  | A   |
|   |  |                          |                     | SHT                                     | OF  |
|   |  |                          |                     | 1                                       | 1   |
| CONTROLS DIVISION • RESEARCH INCORPORATED • MINNEAPOLIS 24, MINNESOTA |  |                          |                     |   |     |

| REVISIONS |      |                       |        |        |         |
|-----------|------|-----------------------|--------|--------|---------|
| SYM.      | ZONE | DESCRIPTION           | DRAFT. | CHECK. | DATE    |
| A         |      | ADD MSFC CONTRACT NO. | DS     |        | 1-17-72 |
| B         |      | REVISED PER PRINT     | JDJ    |        | 5-31-72 |



MSFC CONTRACT NAS 8-26416

COR APPROVAL \_\_\_\_\_, DATE \_\_\_\_\_

REF. SCH. D40391  
WIRING DIA. D40392

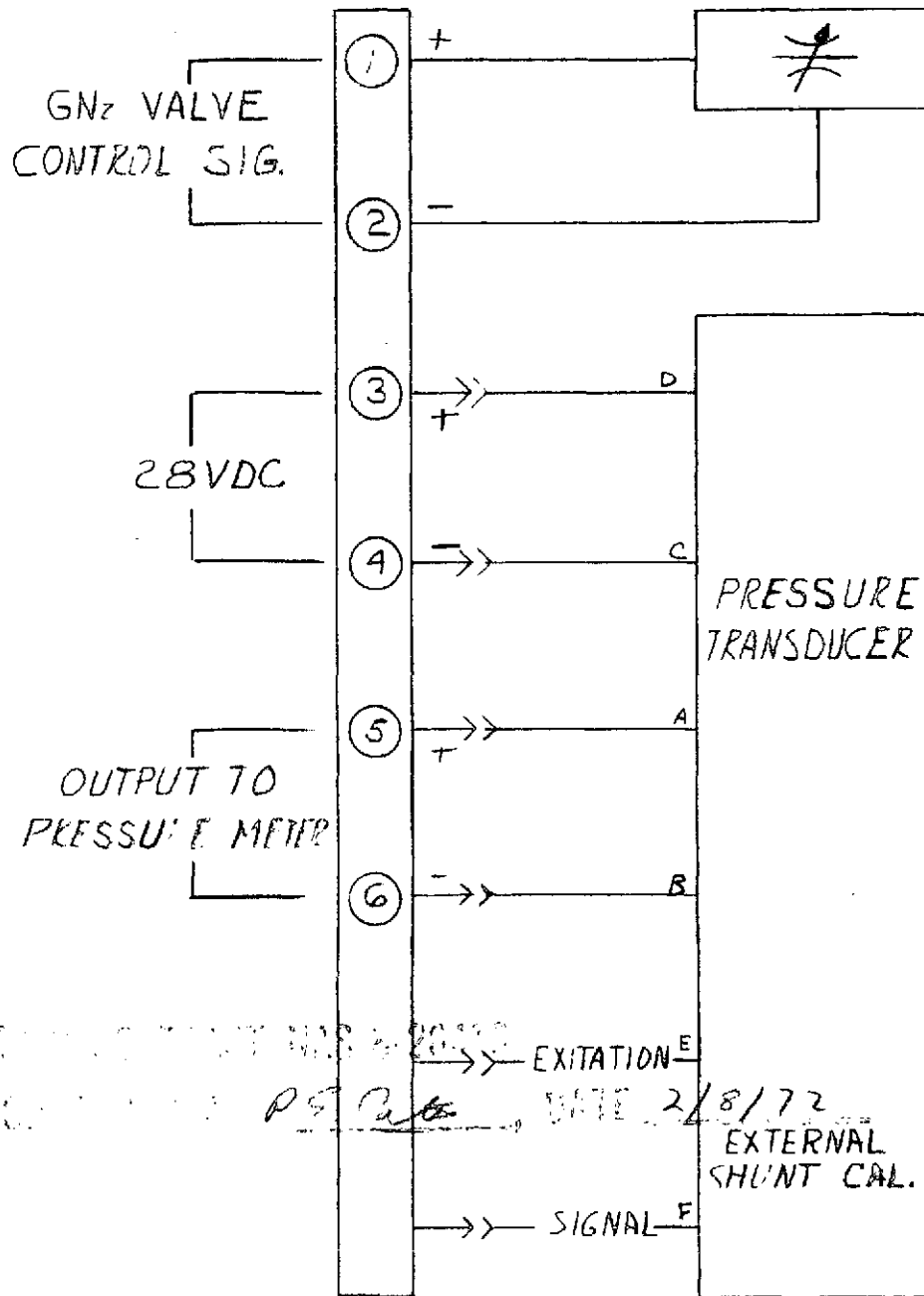
|         |          |
|---------|----------|
|         |          |
|         |          |
|         |          |
|         |          |
|         |          |
|         |          |
| 5008    | D41032   |
| USED ON | ASSEMBLY |

|  |                            |                          |             |  |                  |
|--|----------------------------|--------------------------|-------------|--|------------------|
| DRAFTSMAN<br><b>RMF 12-3-71</b>                  |                            | X = 10'<br>              | M = 10'<br> | UNLESS OTHERWISE INDICATED<br>• RESISTANCE IN OHMS $\pm 10\%$ 1/2 WATT<br>• CAPACITANCE IN MFD $\pm 20\%$<br>• INDUCTANCE IN HENRIES<br>• USE 60/40 ROBIN CORE SOLDER<br>• USE NO CORROSIVE FLUX | MODEL<br><br>    |
| CHECKED<br><b>AYB 1-17-72</b>                    | APPROVED<br><b>1-17-72</b> | CONNECTION NO CONNECTION |             | NUMBER<br><b>A91174</b>  | REV.<br><b>B</b> |
| SCHEMATIC - ARRAY COOLING WATER<br>FLOW SWITCHES |                            |                          |             | SHT. 1 OF 1  |                  |



**CONTROLS DIVISION • RESEARCH, INCORPORATED • MINNEAPOLIS 24, MINNESOTA**

| REVISIONS |      |                    |        |       |         |
|-----------|------|--------------------|--------|-------|---------|
| SYM.      | ZONE | DESCRIPTION        | DRAFT. | CHECK | DATE    |
| A         |      | REVISED PER. PRINT | DS     |       | 1-17-72 |
| B         |      |                    | JDJ    |       | 5-31-72 |



CONNECTOR CN  
X DUCER CANNON  
MC14H-10-SPN

MATE  
CANNON  
MC11B-10-65N

GN2 VLV POSITIONER

| VLV  | J-BOX | TERM | COMP |
|------|-------|------|------|
| TOP  | 66A5  | 1    | +    |
|      | 66A5  | 2    | -    |
| SIDE | 66A5  | 3    | +    |
|      | 66A5  | 4    | -    |
| BTM  | 66A4  | 1    | +    |
|      | 66A4  | 2    | -    |


TRANSDUCER CONNECTIONS  
ALL IN 66A4

| PIN | TOP | SIDE | BTM. |
|-----|-----|------|------|
| A   | 3   | 9    | 15   |
| B   | 4   | 10   | 16   |
| C   | 5   | 11   | 17   |
| D   | 6   | 12   | 18   |
| E   | 7   | 13   | 19   |
| F   | 8   | 14   | 20   |

REF. WIRING DIA. D 46372

|         |          |
|---------|----------|
|         |          |
|         |          |
|         |          |
|         |          |
|         |          |
|         |          |
| 5008    | D41032   |
| USED ON | ASSEMBLY |

DRAFTSMAN  
PMF 12-4-71  
CHECKED  
HVC 12-17-72  
APPROVED  
HVC 12-17-72

K = 10<sup>3</sup> M = 10<sup>6</sup>  
  
 CONNECTION NO CONNECTION

UNLESS OTHERWISE INDICATED  
 • RESISTANCE IN OHMS ± 10% 1/2 WATT  
 • CAPACITANCE IN MFD ± 20%  
 • INDUCTANCE IN HENRIES  
 • USE 60/40 ROSIN CORE SOLDER  
 • USE NO CORROSIVE FLUX

MODEL

TITLE  
SCHEMATIC - COOLING GAS VALVE

NUMBER  
A41172

REV  
B

SMT. 1 OF 1



CONTROLS DIVISION • RESEARCH, INCORPORATED • MINNEAPOLIS 24, MINNESOTA